MACHINE DESIGN

THE PROFESSIONAL JOURNAL OF CHIEF ENGINEERS AND DESIGNERS

EDITORIAL STAFF

Laurence E. Jermy, Editor
John W. Greve, Managing Editor

Associate Editors
Colin Carmichael Richard K. Lotz
Roger W. Bolz

Harry Raech Jr., Assistant Editor

Frank H. Burgess, Art Editor

New York....B. K. Price, L. E. Browne
Chicago.....Erle F. Ross
Pittsburgh.....J. C. Sullivan
Detroit.....A. H. Allen
Washington.....E. C. Kreutzberg
London.....Vincent Delport

BUSINESS STAFF

G. O. Hays, Business Manager

Mary L. Callahan, Advertising Service
Chicago.....H. H. Dreyer, Manager
J. M. Wells, Ass't. Manager
New York.....R. H. Smith, Manager
E. S. Lawson, Ass't. Manager
Cleveland.....H. B. Veith, Manager
Los Angeles.....F. J. Fuller, Manager

CIRCULATION & RESEARCH

J. W. Zuber, Director
Jack C. Gernhard, Readers Service
R. L. Hartford, Market Research

MAIN OFFICE

Penton Building, Cleveland 13, Ohio

BRANCH OFFICES

New York 17.....16 East 43rd St.
Chicago 11.....520 North Michigan Ave.
Pittsburgh 19.....2806 Koppers Building
Detroit 2.....6560 Cass Ave.
Washington 4..1123 National Press Bldg.
Los Angeles 4 130 N. New Hampshire Ave.
London, S.W.1 2 Caxton St., Westminster

Published by The Penton Publishing Co. E. L. Shaner, Pres. and Treas.; G. O. Hays, Vice Pres. and Gen. Mgr.; R. C. Jaenke, Vice Pres.; F. G. Steinebach, Vice Pres. and Secy.; E. L. Werner, Asst. Treas. Published on the seventh of each month.

This Month's Cover: New features of Harley-Davidson motorcycle engine, include hydraulic valve lifters which maintain zero clearance between rocker arms and valves. Illustrated discussion of valve lifter design as well as other features is presented on Pages 144-146 of this issue.

CONTENTS

August, 1948 — **Vol. 20, No. 8**

A Design for Morale in the Engineering Department 89
By Harold A. Bolz

Scanning the Field for Ideas 95

Design Is Primary Topic at Milwaukee Meeting 98

Relay Prevents Short Cycling 106
By Warren Ewald

Production Processes—Part XXXVI—Hot Extrusion of Metals 107
By Roger W. Bolz

How To Design Molded and Extruded Rubber Parts 115
By John H. Gerstenmaier

Channel-Grid Stiffener System—for flat machine panels 118
By Charles Bailey and David Boyd

Applying Time and Motion Study Principles in Design 121
By M. E. Mundel and R. C. Howell

Redesigning To Withstand Shock—with high-speed movie studies 127
By D. L. Pierce

Gear Noise—problems in naval ships 133
By George Wohlberg

Determining Moment of Inertia 138
By Charles E. Crede

Investment Castings—requirements of design 139
By G. A. Stolze

Road Machinery Points the Way (Editorial) 143

Load Capacity and Friction of Pivoted-Shoe Bearings—Part II (Data Sheet) 149
By H. A. S. Howarth

Itemized Index 7
Topics 86
Designs of the Month 144
Applications of engineering parts, materials and processes 148
Assets to a Bookcase 152
Men of Machines 153
New Parts and Materials 155
Engineering Dept. Equipment 172
Noteworthy Patents 174
Business and Sales Briefs 186
Meetings and Expositions 190
Design Abstracts 192
New Machines 198
Helpful Literature 257

Subscription in the United States and possessions, Canada, Cuba, Mexico, Central and South America: One year $10. Single copies, $1.00. Other Countries One year, $15.

Copyright 1948 by The Penton Publishing Company.

Acceptance under Act of June 5, 1934. Authorized July 20, 1934

Low Maintenance Cost . .

High Machine Production

The Dollars-and-cents Advantages of the Airflex Principle

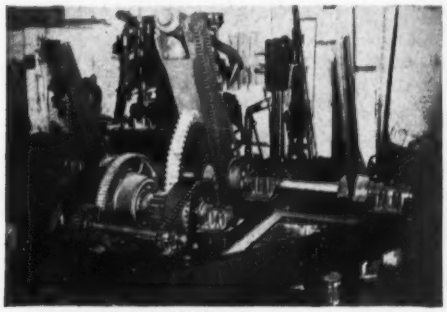
The experience of thousands of satisfied users proves that Fawick-equipped machines do more work—at less cost—and earn more money.

Fawick Clutches adjust themselves. They put an end to wasteful clutch-adjustment down time. They contain no arms, levers or springs to wear or break. In fact, they reduce clutch maintenance costs practically to zero.

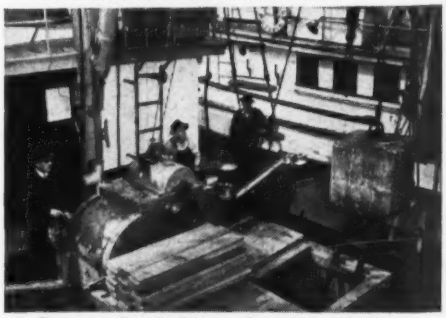
Furthermore, a Fawick Clutch is a shock absorber that protects the entire machine, reduces over-all maintenance expense and adds years to its productive life. It cushions and absorbs shocks, jars, jolts and vibration, preventing unnecessary breakage, undue wear and tear and needless parts replacement costs.

The Airflex principle has proved its advantages under exacting conditions in many fields—petroleum, earth-moving, metalworking, rubber, pulp, paper and others. New applications are being developed constantly.

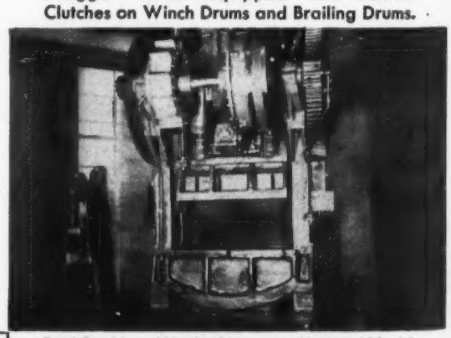
Write our Engineering Department for recommendations of the Fawick elements best suited for your equipment.



Draper Engine Works Company Log Turner equipped with Fawick Forward and Reverse Drive Clutches and Fawick Brake.



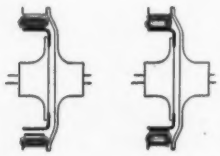
Tacoma Boatbuilding Company Northern Dragger Winch equipped with Fawick Clutches on Winch Drums and Brailing Drums.



Rockford Iron Works Company Model 6½-60 Press equipped with Fawick Clutch and Brake.

HERE'S HOW IT WORKS

Compressed air expands the rubber-and-fabric tube to engage clutch with any degree of "grip" you want. Release the air and clutch disengages.



FAWICK *Airflex* and AIRING **CLUTCH**

FAWICK AIRFLEX CO., INC. 9919 Clinton Rd., Cleveland 11, O.

In Canada, Renold-Coventry Ltd., Montreal, Toronto, Vancouver, Quebec • In Britain, Crofts Engineers, Ltd., Bradford, England

Itemized Index

Classified for convenience when studying specific design problems

Design and Calculations

Amplifier, electronic, Edit. 95
Bars, torsion, Edit. 97
Bearings, pivoted-shoe (data sheet), Edit. 149-151
Camera studies of shock test, high-speed, Edit. 127-132
Car coupler standards, Edit. 100-101
Casting, investment, Edit. 139-142
Device, tension, magnetic, Edit. 97
Die casting, cores in, Edit. 105, 176
Extrusion of metals, hot, Edit. 107-114, 184
Gear noise, Edit. 133-137, 182
Heating, induction, Edit. 176, 178, 180
Jig borer, Edit. 146-147
Loader, gravity, Edit. 95
Lubrication, models for study, Edit. 104-105
Mechanism, rotary impact, Edit. 96
Mechanisms, intermittent, Edit. 98
Moment of inertia determination, Edit. 138
Motorcycle engine, Edit. 144-146
Optical measuring system, Edit. 146-147
Relay, short-cycling, Edit. 106
Rubber parts, molded and extruded, Edit. 115-117
Spline standards, Edit. 101-104
Springs, helical, Edit. 98-100
Time study principles, Edit. 121-126
Valve lifters, hydraulic, Edit. 144-146
Welded machine panels, Edit. 118-120
Welding, projection, Edit. 104

Engineering Department

Equipment, Edit 172; Adv. 45, 159, 182, 263
Management, Edit. 89-94, 162
Supplies, Edit. 172; Adv. 240, 261, 273, 277
Testing equipment, Edit. 170; Adv. 193

Finishes

Protective coatings, Edit. 166

Materials

Adhesives, Edit. 116
Aluminum alloys, Edit 162
Carbon, Edit. 148
Copper alloys, Adv. 56, 96
Glass cloth, Adv. 250
Magnesium alloys, Adv. 64
Molybdenum alloys, Adv. 204
Nickel alloys, Adv. 19
Nickel-silver, Adv. 52
Plastics, Edit. 148, 162; Adv. 18, 53, 216
Rubber and synthetics, Edit. 115; Adv. 57, 246
Sandwich, Adv. 256
Silicones, Adv. 176
Steel, Edit. 152; Adv. 23, 87, 287
Steel, stainless, Edit. 168

Parts

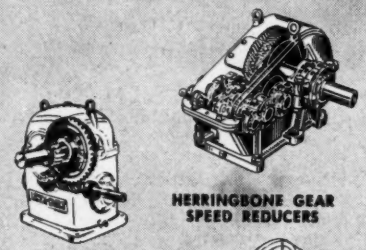
Actuators, Edit. 156
Bearings:
  Ball, Adv. 6, 11, 194, 197, 271
  Nonferrous, Adv. 231
  Roller, Adv. 201, 213, 230, back cover
  Sleeve, Edit. 149-151; Adv. 38, 48, 157, 224, 255, 267, 268
Bellows, Edit. 116; Adv. 31
Belts, Adv. 54, 66, 235
Brakes, Edit. 168
Bushings, Edit. 160
Carbon parts, Edit. 148; Adv. 77, 236
Castings:
  Centrifugal, Adv. 280
  Die, Edit. 105, 176; Adv. 24
  Investment, Edit. 139-142; Adv. 69
  Sand, Edit. 152; Adv. 32, 192, 252, 262, 283
Chains, roller, Edit. 148; Adv. 40-41, 232, 244, 259
Clutches, Edit. 160, 166; Adv. 4, 55, 58, 265, 272
Collars, Adv. 270
Controls (see Electric, Cable, etc.)
Conveyors, Edit. 160
Counters, Edit. 168; Adv. 232, 281
Couplings, Edit. 155; Adv. 13, 20-21, 73
Electric accessories, Edit. 170; Adv. 281
Electric controls:
  Contactors, Edit. 127-132
  Electronic, Edit. 95, 192; Adv. 208-209, 225
  Magnetos, Adv. 63
  Rectifiers, Adv. 42, 173
  Relays, Edit. 106, 162, 164, 166, 168, 170; Adv. 65, 187, 190, 281
  Resistors, Edit. 127-132; Adv. 191
  Solenoids, Edit. 158
  Starters, Adv. 185, 189
  Switches, Edit. 160, 162; Adv. Inside front cover, 29, 67-68, 265
  Thermostats, Edit. 164; Adv. 248
  Timers, Edit. 160; Adv. 178, 202, 263
  Transformers, Adv. 266
Electric motors, Edit. 155, 156, 158, 162, 164; Adv. 15, 22, 26, 28, 51, 74-75, 82-83, 88, 171, 175, 195, 220, 249, 271, 272
Engines, Edit. 144-146, 166, 170; Adv. 269, 275, 279, 283, inside back cover
Fastenings:
  Blind, Adv. 10
  Locking, Edit. 170; Adv. 1, 35, 179, 186, 226
  Nuts, bolts, screws, Edit. 162, 166; Adv. 37, 39, 72, 161, 165, 214, 245, 276, 285, 290
  Rivets, Adv. 270
  Special, Adv. 206
Felt parts, Adv. 229
Filters, Adv. 282
Fittings, Edit. 156, 158; Adv. 36, 228
Forgings, Adv. 202, 265, 275
Gages, pressure, etc., Adv. 79
Gears, Edit. 133-137, 182; Adv. 5, 25, 34, 62, 198, 212, 247, 264, 266, 268, 271, 275, 277, 279
Heat exchangers, Adv. 50
Hydraulic and pneumatic equipment:
  Accumulators, Edit. 170; Adv. 243
  Cylinders, Edit. 144-146; Adv. 61, 264
  Oils, Adv. 12
  Pressure regulators, Adv. 267
  Pumps, Adv. 9, 16, 60, 177, 270, 276
  Systems, Edit. 160; Adv. 199, 239, 263, 273
  Valves, Edit. 155, 158, 164, 168; Adv. 219, 260
Joints, Edit. 156; Adv. 217, 280
Lamps and lighting, Edit. 172
Lubrication and equipment, Edit. 104-105, 174; Adv. 167, 211, 262, 269
Machined parts, Adv. 204
Magnets, Edit. 97, 162
Motors (see Electric motors)
Mountings, Edit. 116, 174; Adv. 163
Pins, dowel, Edit. 156
Piping and equipment, Adv. 46
Plastic parts, Adv. 274
Pneumatic equipment (see Hydraulic and pneumatic)
Powder-metal parts, Adv. 49
Pulleys and sheaves, Edit. 155; Adv. 222, 270, 274, 284
Pumps (see also Hydraulic and pneumatic), Edit 155, 156; Adv. 47, 200, 206, 273, 282
Rings, Adv. 85
Rubber and synthetic parts, Edit. 115; Adv. 80, 210, 223
Screws, power, Edit. 174
Seals, packings, gaskets, Edit. 174; Adv. 2, 12, 76, 78, 81, 169, 233, 254
Shafts, flexible, Adv. 260, 269
Sheet-metal parts, Adv. 234, 272, 274
Speed reducers, Adv. 33, 43, 218, 221, 241
Springs, Edit. 98-100; Adv. 184, 277, 285
Stampings, and formed parts, Adv. 44, 251
Tachometers, Edit. 164
Thermometers, Adv. 268
Transmissions, variable-speed, Edit. 158; Adv. 8, 27, 70-71, 188
Tubing:
  Condenser, Edit. 166
  Finned, Adv. 237
  Flexible, Adv. 283
  Metallic, Adv. 17, 30, 215, 227, 253, 289
  Nonmetallic, Edit. 164
Universal joints, Adv. 238, 264, 279
Valves (see also Hydraulic and pneumatic) Adv. 84, 285
Vibrators, Adv. 14
Weldments and equipment, Edit. 104, 118-120; Adv. 183
Wheels and casters, Adv. 205, 276
Wire and wire products, Adv. 180, 262

Production

Balancing, Adv. 59, 261, 267
Broaching, Edit. 102-103
Extrusion, hot, Edit. 107-114, 184
Hardening, Edit. 176, 178, 180
Hobbing, Edit. 103-104
Machines, special, Adv. 203
Measuring, Edit. 146-147
Tools and accessories, Adv. 181, 266

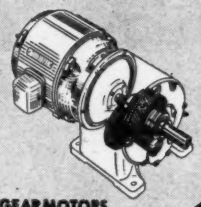
MACHINE DESIGN is indexed in Industrial Arts Index and Engineering Index Service, both available in libraries generally

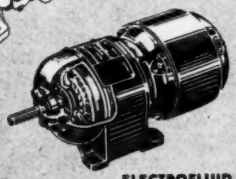
THE COMPLETE LINE OF
LINK-BELT
POWER TRANSMISSION
MACHINERY

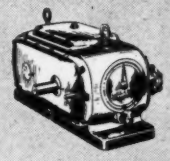

HERRINGBONE GEAR SPEED REDUCERS

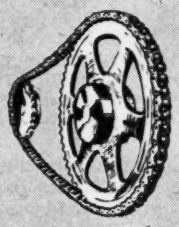
WORM GEAR SPEED REDUCERS

HELICAL GEAR SPEED REDUCERS

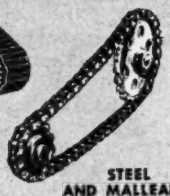

GEARMOTORS


ELECTROFLUID DRIVES


P.I.V. GEAR SPEED VARIATORS


SILVERLINK ROLLER CHAIN DRIVES

SILENT CHAIN DRIVES


STEEL AND MALLEABLE CHAIN DRIVES

V-BELT DRIVES

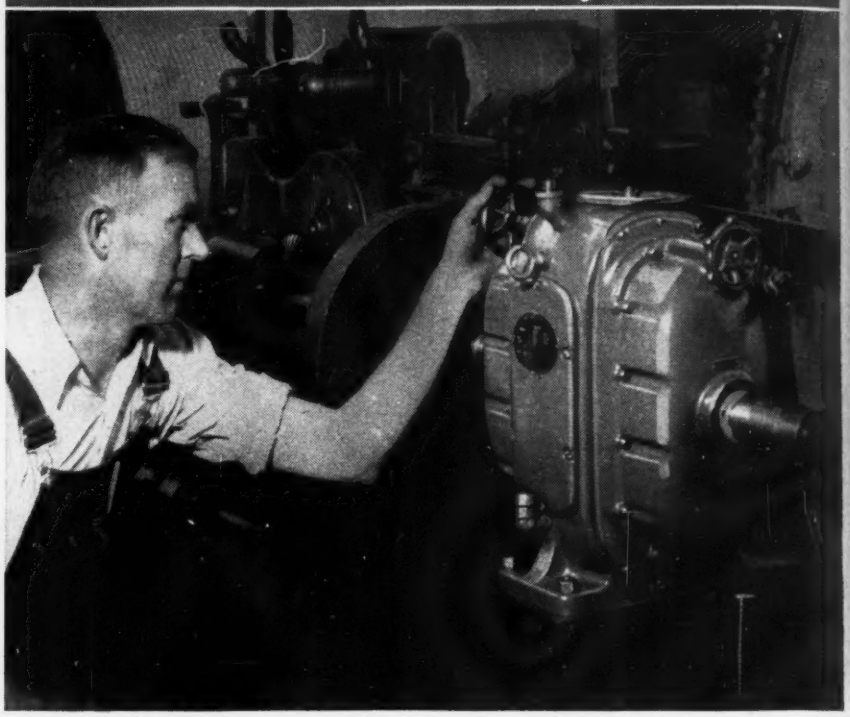
UNMOUNTED BALL AND ROLLER BEARING UNITS

ROLLER BEARING MOUNTED UNITS

BALL BEARING MOUNTED UNITS

BABBITTED BEARINGS

SELECT---*and Maintain* YOUR IDEAL MACHINE SPEED WITH P.I.V. GEAR *Speed Variator!*



Wherever precise speed is a factor in any manufacturing process, the unique P.I.V. Gear speed variator gives outstanding satisfaction.

With this unit, power is transmitted positively through an all-metal chain, making tooth-to-tooth contact with metal wheels. Speeds can be varied infinitely within range of the unit and once selected, the chosen speed is maintained accurately. Speed is changed while the drive is running, by a small hand wheel or by automatic or remote control.

For precise speed control in any type of industrial application use the P.I.V. Gear. Built in a wide range of sizes, and types, fully described in Book 1874.

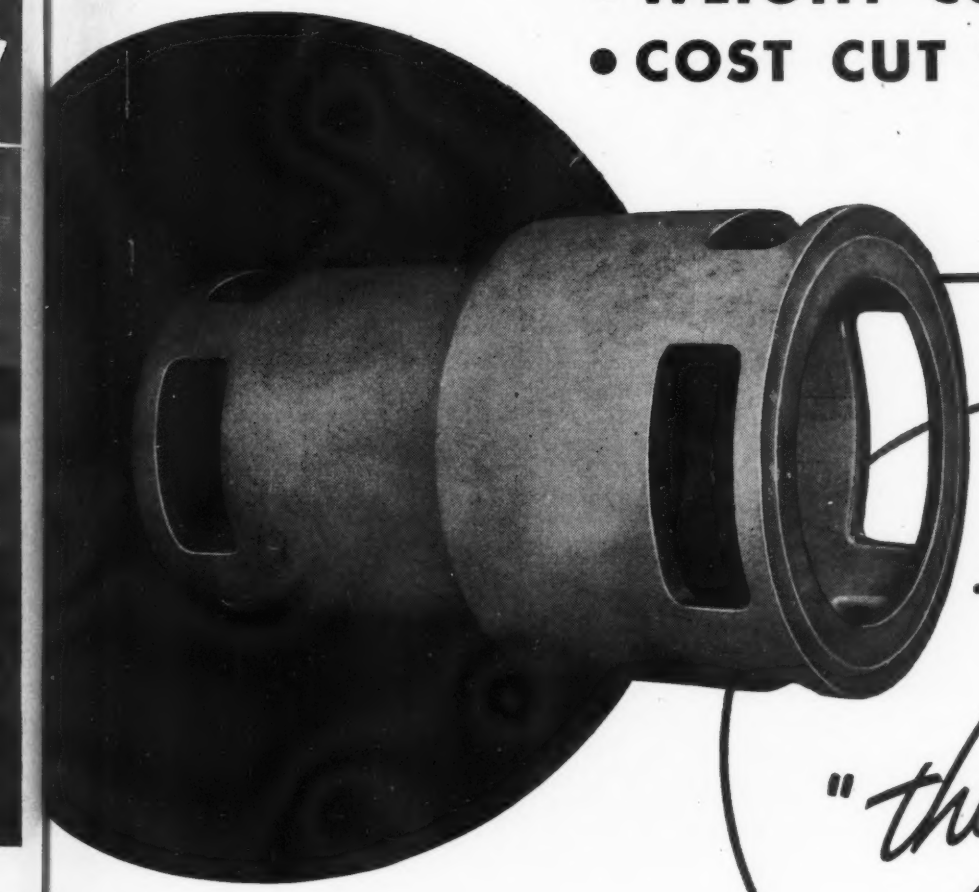
LINK-BELT COMPANY

Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Dallas 1, Minneapolis 5,
San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8.
10,964 Offices, Factory Branch Stores and Distributors in Principal Cities.

LINK-BELT

Power Transmission Machinery

• MACHINING CUT 35%
• WEIGHT CUT 31%
• COST CUT 19%



...BECAUSE A DESIGNER *"thought in Circles!"*

Here's the story of a generator frame that was made lighter, better and cheaper through a process known as "thinking in circles".

Originally made from a heavy cast cylinder, the frame used to be hogged out to provide thickness where needed, and to develop the proper contour to accommodate the electrical parts inside.

Then the manufacturer, "thinking in circles", called on Dresser's 65 years of experience in making circular metal objects.

Today, the frame is made by Dresser out of four accurately formed and welded steel rings, each having the size, shape and metallurgical properties for its particular function. Two rings are made of special low hysteresis steel, the others from ordinary mild steel. Practically no machining is required.

Perhaps in your own products there are problems which might be solved by "thinking in circles" with Dresser engineers who have behind them the highly specialized skill and equipment needed for such work.

It will cost you nothing to find out.

Your inquiry, accompanied by a sketch or blueprint and description of product use, will bring you preliminary recommendations and estimates. No obligation, of course.

DRESSER MANUFACTURING DIVISION, 81 FISHER AVE., BRADFORD, PA.

DRESSER RINGS

ONE OF THE DRESSER INDUSTRIES

HOW "THINKING IN CIRCLES" SAVES YOU MONEY...

Dresser starts with stock of the desired cross section . . . Forms and expands it to accurate size and shape . . . Flash welds it under rigid control . . . Leaving you little or no finishing to do.

Topics

TOUGHNESS of welded joints in steel structures may be determined by a method proposed in a report which was prepared for the Watertown Arsenal Laboratory. Bend tests of specimens having welded joints are compared with test results on similar specimens of unwelded metal with and without notches. The tension side of the welded specimen should be the irregular surface of the weld.

ANODIZING of aluminum rivets in combination with chemical polishing in a new "mass" process developed by Colonial Alloys Co. gives a brilliant coating which may be dyed almost any color. The protective coating is hard, abrasion and corrosion resistant. It does not peel or craze.

AUTOMOTIVE TIRES without tubes have been developed by Goodrich. Sealant of soft, sticky rubber lines a rayon-cord carcass. Beaded section fits the wheel flange, sealing against air loss.

INDICATIVE of increased use of aluminum, particularly in mobile or portable machines, is the substitution of this metal for steel in a number of parts for the new Ford cars. Consisting mostly of stamped parts, 25 pounds of aluminum replace 57 pounds of steel for 14 parts.

PRESENT PRODUCTION of aluminum has increased more than seven-fold over prewar average. Inasmuch as very little of the metal is being used for aircraft and military equipment, it is going into expanded and new industrial uses. Production rate is more than two billion pounds annually.

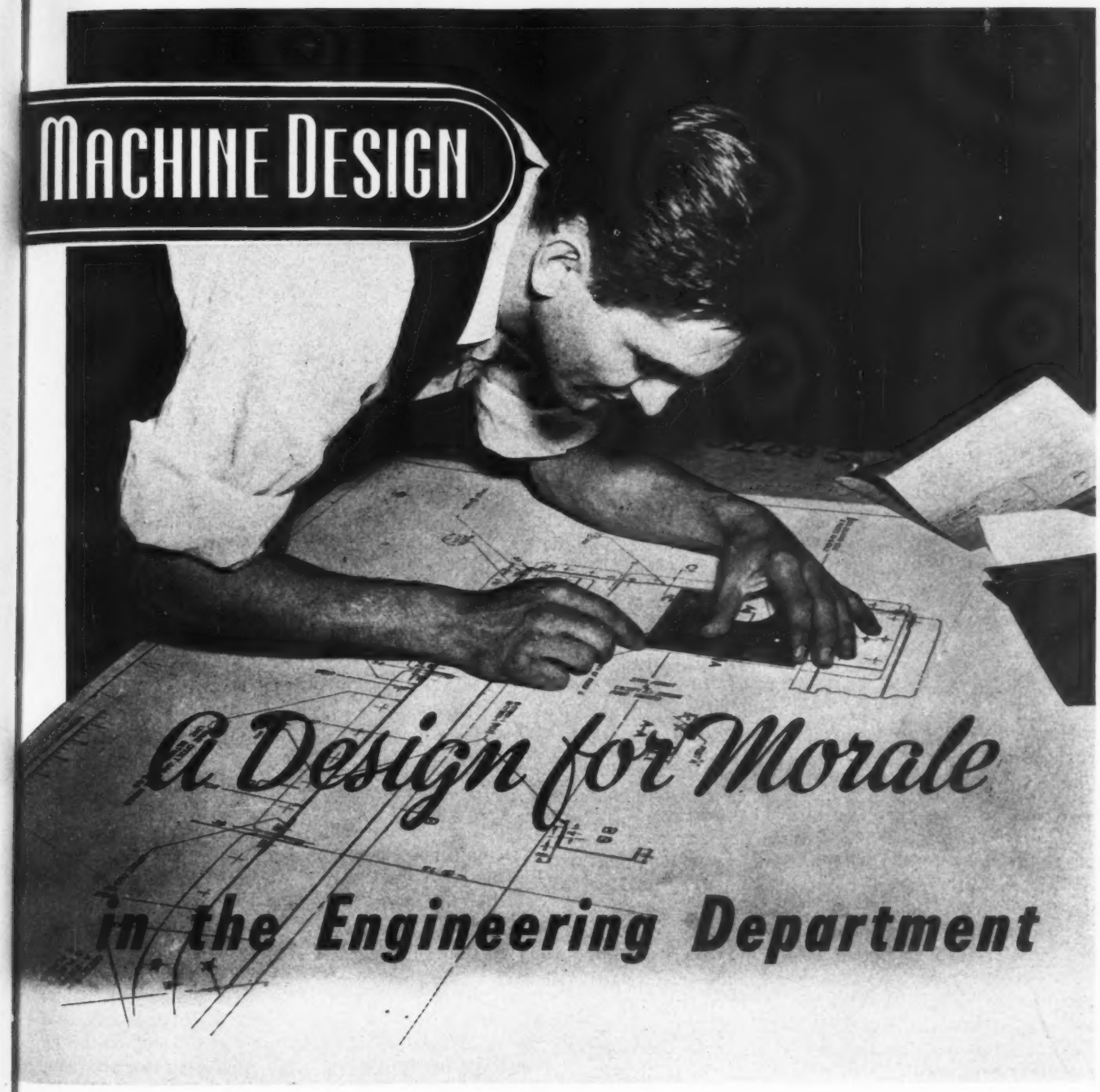
IRON, when freed of occluded gases, possesses the durability and the electron emission characteristics required in electron tubes. It can effectively replace molybdenum and nickel for these uses but the production process is more tedious and costly. In a process developed by the Japanese, the iron is deoxidized with silicon and aluminum in an induction furnace. Further purification is obtained by passing a stream of hydrogen over the iron at 1100°C, leaving less than 0.004 per cent oxygen.

ALUMINUM being relatively "dead" acoustically, is being used for ducts because it does not transmit sound waves as freely as conventional materials. Also it tends to absorb contraction and expansion noises associated with heating equipment.

HEAT-FLOW PROBLEMS are readily solved by a special type of calculating machine, developed at Columbia School of Engineering, which is known as a "heat and mass flow analyzer". Its principle is based on the electric analogy method in that flow of heat is measured in the same way as electric current. Characteristics of finned heat exchangers, deicing of airplane windows, heat generation in brakes, and other specific heat flow problems in industry have been solved which, by mathematical methods, would be either impracticable or time consuming.

RESISTANCE of aircraft structural materials to spontaneous cracking while exposed to the atmosphere under stress can be estimated more quickly on the basis of new criteria developed by the U. S. Army Air Forces. Reports on the research, available from the Office of Technical Service, Department of Commerce, tabulate 23 aluminum alloys and 12 magnesium alloys in order of resistance to stress corrosion.

NATIONAL ELECTRICAL SAFETY CODE, combining the first five parts previously issued separately, has been published recently by the National Bureau of Standards. Included are installation and maintenance rules for electric utilization equipment as well as safety rules for operation.



A Design for Morale in the Engineering Department

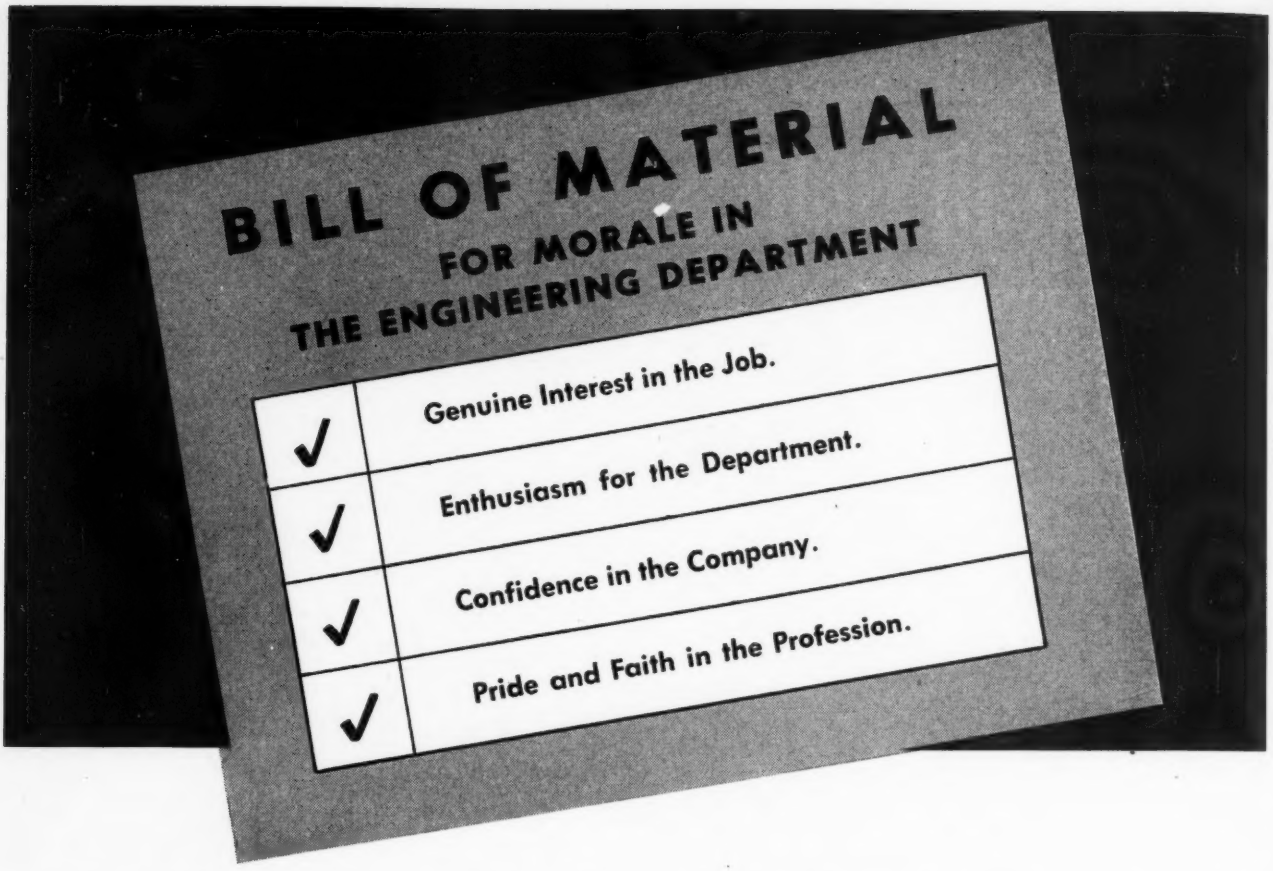
By Harold A. Bolz

Head
Dept. of General Engineering
Purdue University

I WOULDN'T take the job for all the money in the world but for you I'll do it for nothing." This reply of a prominent executive to a request by an acquaintance for assistance on a professional project demonstrates the old precept that men will serve for other than material reasons. The foremost of these reasons, probably, is loyalty and loyalty is one of the major products of morale. The Army has proved that there is no substitute for morale. Industry has learned the same lesson in dealing with workers, but the morale of engineers so often is taken for granted with unfortunate consequences that an analysis of this problem in the engineering department seems timely.

Morale is a mental state—one which renders a person capable of unusual accomplishments. Being a mental state, it is influenced by more than material considerations. While the interests and satisfactions governing morale are affected by such matters as wages and bonuses, they are primarily the results of individual personal feelings, reactions, tastes and opinions. As such, morale is a psychological problem requiring close consideration of each of the many aspects of human behavior which affect it. The apparent

Photograph, courtesy Glenn L. Martin Co.


BILL OF MATERIAL
FOR MORALE IN
THE ENGINEERING DEPARTMENT
✓ Genuine Interest in the Job.
✓ Enthusiasm for the Department.
✓ Confidence in the Company.
✓ Pride and Faith in the Profession.

complexity of this problem, however, should not discourage the application of simple but effective common sense principles of human relations.

MORALE ANALYZED: Someone has said that the ultimate in morale is reached when each employee believes that he has the best job in the best department in the best company in the best industry in the best country in the world. Whether such a complete state of satisfaction on the part of any considerable portion of the staff would really keep an organization vigorous and progressive is questionable. It seems, however, to be a goal the striving for which, rather than the attainment, will build morale of a high order.

In any attempt to analyze the elements of which morale is composed, the relationship of the individual to the details of his job comes first to mind. This suggests one of the prime ingredients of morale, *interest in the job.* Interest here is to be interpreted in the active sense denoting a desire not merely to do the job to the extent of satisfying the minimum requirements but to carry it through to completion in the most efficient manner. It implies a willingness to exercise whatever initiative and ingenuity may be required to surmount unforeseen obstacles.

A second fundamental element of morale may be described as *enthusiasm for the department.* The involved nature of modern industrial procedures requires the highest possible degree of group effort. This implies competent employees, interested in their jobs individually and also jointly as a group. It would be difficult, indeed, to conceive of a high grade of morale pervading any department where enthusiasm for that department was evinced by only a few.

Job interest and departmental enthusiasm lead to a third requirement for sound morale, namely *confidence in the company.* Loyalty, one of the prime results of morale, is predicated on confidence. Confidence in the company is born of confidence in one's supervisor, in the department head and in the body of management itself. Morale dies when confidence is lost and confidence in the company cannot be sustained without the hope of recognition for work well done, without the assurance of reasonable employment security, and without evidence of reciprocal faith by management in the employee. No company can gain the full confidence of its employees unless it selects its new staff members intelligently and trains them thoroughly to understand and discharge their responsibilities properly, unless it rates and compensates its employees fairly, unless it provides its employees with adequate and comfortable working facilities and competent supervision and unless it expresses reasonable respect for the intelligence and judgment of its employees by keeping them informed of changes in policy which affect them and of the reasons for such changes.

Professional Status Potent Influence

In the case of engineers, morale involves the additional ingredient of *pride and faith in the profession.* Engineers have long hoped that their calling would some day be recognized and classed with the established professions. As will be explained in subsequent paragraphs, real progress is being made in this respect and engineers are finally gaining their long-sought recognition as professional practitioners. They are proud of this recognition and will work hard to

uphold the tenets of the profession. This means that the morale of this group is strongly influenced by the degree to which its working atmosphere is conducive to the growth and development of professional consciousness.

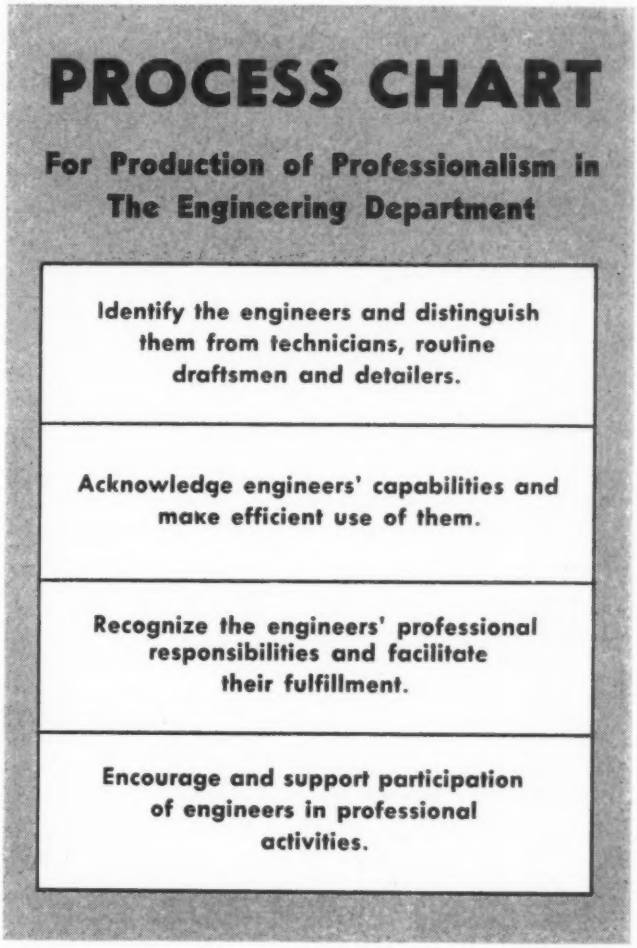
Morale may be compared to a complex machine which requires years of effort in the designing and building, which produces marvelous results while it is properly adjusted, serviced and maintained, but which ceases to function if any one of its many bearings and mechanisms is overlooked by the oiler.

ENGINEERS AS HUMAN BEINGS: Engineers are *people* and as such should respond to the basic psychological and common-sense approaches that have been found effective in handling human beings in general. Much could be said on this subject and it could be said in terms considerably more abstruse and profound than the ones being written here. But let us take a simple approach to the problem of analyzing engineers as human beings. Americans seem to be motivated, or influenced at least, by two conflicting feelings, that of *individualism* and that of *gregariousness*. Each of us likes to be recognized as a distinct and outstanding individual but at the same time we have an intense desire to "belong", to be one of "the gang". The first step in developing morale is to accept the fact that engineers, too, probably harbor these somewhat contradictory feelings and that their resulting attitudes and aspirations must be satisfied to a reasonable extent if any degree of satisfaction on the job is to be realized.

Proper Recognition Important

As an individual the engineer in general likes to feel that he is the man for his job, that he is the required expert. He likes to feel that he is intelligent, ingenious and a good judge. As such, he believes that he should be treated with reasonable respect and that his employer should have sufficient confidence in him to invest in adequate tools, proper facilities and competent help and supervision for him. Like any normal person he acknowledges the probability of his making occasional mistakes but expects courteous correction and not public criticism. He wants credit for his accomplishments and, in fact, delights in generous praise of his work if it is tendered in sincerity. Ordinarily he is highly respected by his family who are proud of him and not at all reluctant to spread his praises among the neighbors and relations. Consequently, on the job, too, he has a right to be respected. He likes to know that his superiors are interested in him and in his family but resents any meddling or undue curiosity in regard to his personal affairs. While he enjoys personal recognition, obvious favoritism displayed by his superiors may be very embarrassing to him. Although he wants consideration he likes to feel that he can take care of himself and his family. This is the engineer as a human being, jealous of his personal pride, "face" or self respect and striving to make his mark as an individual in a busy world of struggling masses of individuals.

As a gregarious person the engineer works with his fellow men on the great problem of maintaining individuality but still belonging as one of the group. In spite of an intense desire to stand out as a separate human entity the engineer as a man likes to feel that he is accepted as a member in good standing of the groups in which he lives, works and plays. He likes to be able to work and get along with others. He likes to know his place in his organization and how he stands relative to his fellow members. He is happier in an organization in which he has confidence, in which his grievances as well as his accomplishments will be dealt with in fairness and with logic. He wants to have confidence in his superiors as well as in his subordinates and he works more effectively when his faith in the "proper channels" is sustained. He does not necessarily demand a voice in setting the policies of his organization but he wants to be able to understand these policies and the basis upon which they were established.


PROCESS CHART
For Production of Professionalism in The Engineering Department
Identify the engineers and distinguish them from technicians, routine draftsmen and detailers.
Acknowledge engineers' capabilities and make efficient use of them.
Recognize the engineers' professional responsibilities and facilitate their fulfillment.
Encourage and support participation of engineers in professional activities.

Thus, the engineer is just another human being and, since in this respect he is like all the rest of us, he will respond readily to the basic precepts of all human relations. Of these, the Golden Rule is the real fundamental. While this rule of treating others as we would be treated seems basically unselfish, it derives its force and effectiveness from the inherent human selfishness that motivates us engineers as human beings. To apply the Golden Rule successfully one must first understand himself, his motives and de-

A QUALITATIVE ANALYSIS OF THE ENGINEER

The Human Component

1. Possesses pride and self respect—responds to courtesy and deference.
2. Appreciates recognition in the form of due credit, praise and advancement.
3. Likes to stand out from the crowd through recognition of his individuality.
4. Wants to belong,—to work with, not for.
5. Wants to be on a winning team—to have faith in his subordinates, co-workers, superiors and in the organization.
6. Likes to know his place in the organization and to be dealt with through proper channels.
7. Wants to understand management policies, the reasons for their inception and subsequent modifications.
8. Wants to do a good job, which requires the best possible tools, facilities, assistance, training and supervision.
9. Expects fair treatment with grievances as well as accomplishments considered without prejudice.

The Professional Component

1. Expects to be of service, free of any geared connection to the clock.
2. Should observe high ethical standards with personal integrity and working ideals guarded and promoted by management.
3. Must assume confidential responsibility—his capabilities must be recognized and he be allowed to "carry the ball"
4. Bears the responsibility for advancing and disseminating engineering knowledge and needs encouragement to enlarge his own knowledge and to exchange ideas with contemporaries through conferences, talks and publications.

sires. Consequently, to handle others successfully one must first determine how he himself would be handled most effectively. In dealing with engineers, then, one merely needs to recognize that as human beings like himself they:

1. Like to be understood and recognized as distinct individuals and not as standardized robots
2. Must maintain their individual pride and self respect among their fellows
3. Appreciate courteous treatment
4. Will support the superior who "goes to bat every time" for them
5. Like to feel that their judgment, initiative, ingenuity and efforts are valued
6. Expect a fair and square deal in all matters—including fair pay, reasonable and comfortable working conditions and reasonable security.

ENGINEERS AS PROFESSIONAL MEN: While there are still questions in the minds of certain skeptics as to whether engineering is really a profession in the strict sense of the word, the trend among engineers is definitely in the direction of developing true professional stature. The national engineering societies singly and jointly are becoming increasingly active in stimulating professional consciousness among their members. In the state licensing laws for registered professional engineers we finally are realizing a means of defining the term "engineer" legally.

Although this definition was framed with advice from the various professional engineering groups it admittedly is not perfect and will undergo improvements in the course of its application. Most significant to engineers, however, is the fact that this is the first legal step of national scope toward the establishment of engineering on the status enjoyed by the longer recognized professions of medicine and law.

Membership in a founder engineering society or licensing by the state will not, individually or jointly, guarantee that the ones so marked will conduct themselves always in a genuinely professional manner. Such membership and licensing, however, do offer the professional engineering practitioner means of identifying himself as part of a group which is attaining rapidly growing acceptance and recognition among the established professions.

Engineers are beginning to feel and act more and more like true professional men; they like to be considered as professional men and they are willing to fulfill the obligations pertaining thereto. Now then, exactly what does this mean? What is the makeup of the professional engineer compared to any other engineer?

The Committee on Professional Recognition of the Engineers' Council for Professional Development for 1945 specified the attributes of a profession and its practitioners as follows:

Of a Profession:

1. It must satisfy an indispensable and beneficial social need
2. Its work must require the exercise of discretion and judgment not subject to standardization
3. It is a type of activity conducted upon a high intellectual plane
   (a) Its knowledge and skills are not common possessions of the general public; they are the results of tested research and experience and are acquired through a special discipline of education and practice
   (b) Engineering requires a body of distinctive knowledge (science) and art (skill)
4. It must have group consciousness for the promotion of technical knowledge and professional ideals and for rendering social services
5. It should have legal status and must require well-formulated standards of admission.

Of Professional Practitioners:

1. They must have a service motive, sharing their advances in knowledge, guarding their professional integrity and ideals, and tendering gratuitous public service in addition to that engaged by clients
2. They must recognize their obligations to society and to other practitioners by living up to established and accepted codes of conduct.
3. They must assume relations of confidence and accept individual responsibility
4. They should be members of professional groups and they should carry their part of the responsibility of advancing professional knowledge, ideals, and practice.

Note in these specifications the *motive of service* to society and fellow practitioners, the recognition of *high standards of conduct,* the assumption of *confidential responsibility* and the responsibility for *advancing professional knowledge, ideals and practices.* If the engineers in any organization choose to feel that they possess or may eventually attain these attributes, can that organization possibly fail to gain by encouraging and promoting so noble a feeling? Here is a potential morale builder that is grossly neglected in many industrial concerns.

It is true that it would be no small problem in many organizations to draw a clear line between the professional engineers and the technicians, between the responsible engineers and the engineering aids, or between the responsible designers and the draftsmen and detailers. Furthermore, too definite a distinction between these groups may conceivably demoralize some organizations, especially the smaller ones, by promoting a class consciousness to the detriment of wholesome group co-operation. It seems, however, that this problem could be handled in industry with the same success that is attained in hospitals and medical clinics if approached cautiously and tactfully and with constant consideration of the mutual welfare of the respective organization and its members.

The professional spirit—implying as it does the motive of service, high standards of conduct, and a personal sense of responsibility for the successful fulfillment of assignments, the advancement of knowledge, and the maintenance of high ideals and ethical practices—is as important to any modern organization as is the philosophy of free enterprise itself. Lacking this spirit the future creators and developers of products and organizers and controllers of production could conceivably retrogress to the level of clock watchers and mental automatons. Without it the individual can grow and develop only at the expense of his associates and their organization, for striving without serving, authority without responsibility and leadership without ethics breed selfishness,

discourage teamwork and destroy morale. It appears, then, that professionalism is a characteristic essential to department heads and highly desirable in the ranks of all engineers. How can professionalism be encouraged and cultivated to the betterment of engineering department morale? While there is no simple answer to a question of this type which involves the vagaries of human emotions, ambitions, reactions, tastes and prejudices, the following guiding principles may be helpful in arriving at solutions for particular situations:

1. *Identification of engineers and distinguishment from the draftsmen, detailers, engineering aids and other technicians.* The extent to which this may be carried out in any organization of course, depends upon personnel factors peculiar to that organization. While segregation of engineers may enhance the morale of this group, such morale will be dearly bought if it results in snobbishness, complacency and other characteristics conducive to friction with other groups in the organization.

Creative Work is Real Criterion

The specific criteria for identifying the real engineers in any organization may vary according to company traditions and requirements. In general, however, the requirements for membership in the founder engineering societies and for state licensing are desirable guides from the professional standpoint. Regardless of the standards adopted it must be recognized at all times that engineering performance on the job is paramount to past accomplishment. It is *creative work actually performed* and not the string of degrees, certificates and memberships alone that counts. Consequently, no table of criteria for identifying engineers should be so rigid as to discourage creativeness and professional aspiration in the neophyte who has not had a complete formal training.

2. *Acknowledgement and use of the special capabilities of trained engineers.* The most common complaint of young engineering graduates who report to their former professors concerning their first employment after graduation is that their knowledge and abilities are underestimated and their energies are not utilized to any reasonable degree of efficiency. Many industrial training programs for young engineers, instead of exercising and developing to the fullest the mental muscles of the trainees and calling for the best that they have in initiative and ingenuity, sow the seeds of diffidence and irresponsibility upon the assumption that the trainees know nothing and need to be "broken in" on insignificant and often useless assignments. The spirit, professional fiber and reputation of the entire engineering staff will be strengthened if new engineers are very carefully selected, initiated thoroughly but speedily to their new environment and then assigned to projects which, however small, demand knowledge of engineering fundamentals and the engineering approach, projects which impose real responsibility for completeness and accuracy and which require follow-through on all details. This is a rigorous system but it develops vigorous engineers with wholesome morale.

3. *Recognition of the engineers' professional responsibilities.* If it is the professional obligation of the engineer to serve, to assume important responsibility, to advance knowledge and to practice ethical conduct, it naturally will benefit any employer of engineers to recognize these obligations and expect them to be fulfilled.

The story of a Purdue graduate, a young but capable designer, will serve to illustrate this point. Although he is responsible for basic engineering designs and decisions concerning design features of the company's products, he is stationed with other designers among routine draftsmen, tracers and detailers and required to "punch the clock" for pay on the hourly basis. "I thrive on responsibility", he states, "but I cannot control my conception of ideas by the clock. When the quitting bell rings and the gang rushes for that clock I often would like to stay at the board to avoid breaking my train of thought. But a certain personnel pressure from the rest of the group would react against me and the others who feel as I do if the boys saw us take too much overtime. Actually, I don't drop the job when I punch the clock. Like many engineers that I know I take it home with me and nurse it through because I know that 'it's my baby'! I resent being classed by the company as a clock watcher and feel that I could produce much more efficiently if my responsibilities were recognized by management".

4. *Encouragement of professional activities.* If professionalism is acknowledged as an asset to engineers employed in industry it is important that employers not only promote the practice of its ideals and principles on the job but encourage company engineers to take an active part in the functions of their profession, especially that of advancing its ideals and organized technical knowledge. State licensing, membership in engineering societies, and participation in society activities and programs by company engineers are recognized by progressive organizations as essential to the growth and development of their engineering staffs and to the leadership of their products in the competitive field. The sponsorship of society memberships, technical papers and discussions by the company not only gives it representation and recognition in leading technical circles outside the plant but bolsters the prestige and morale of its engineering staff within the organization.

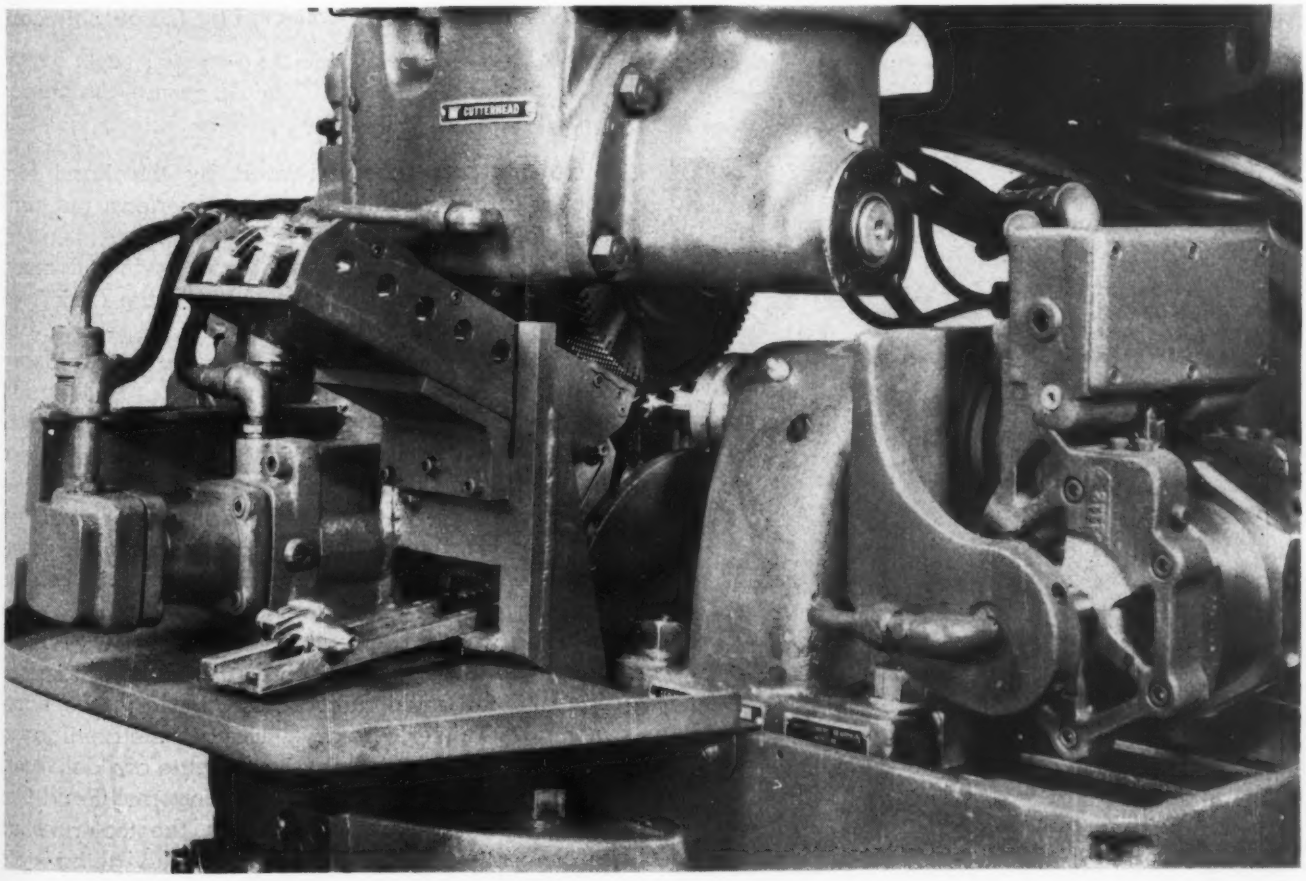
Tremendous Stake in the Future

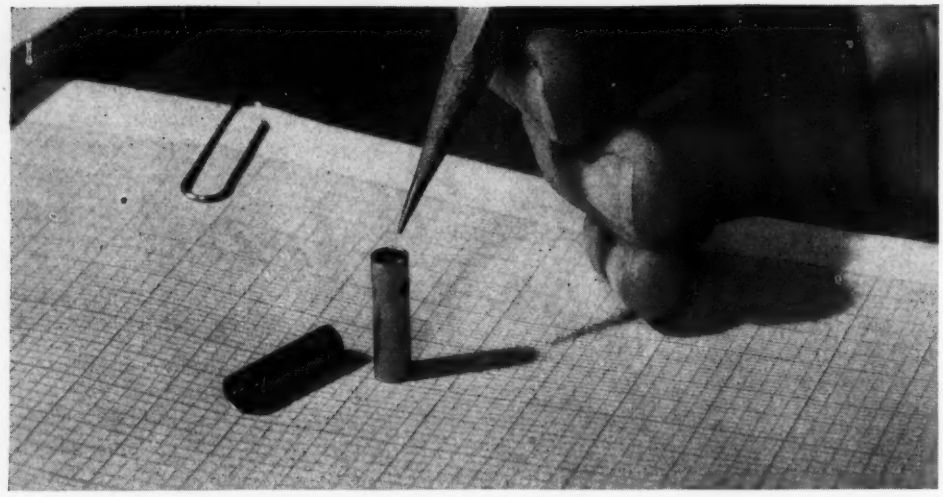
Considering the potent effect of technical and scientific advances on new developments in industrial products, processes and methods, the importance to industry of the well-trained engineer with professional qualities must be recognized in an active way. The services of this group of employees must not only be recognized as important but must be encouraged and developed to the highest degree of effectiveness by constant positive attention to the technical, professional and human factors involved. If it is remembered that the engineer is a human being and that he wants to be a true professional practitioner and if he is treated accordingly, his morale will be sound—and good morale does remarkable things.

Scanning THE FIELD for Ideas

Gravity loading mechanism supplies the gear shaving machine, below, with workpieces and provides for continuous operation as long as the magazine is kept loaded. Developed by the National Broach and Machine Co., the mechanism employs an air-operated loader to carry the work from the magazine to the shaving position. At the start of the cycle, the machine headstock and tailstock are in retracted position. The loader with a work gear moves toward the cutter and meshes the work with it. The head and tailstocks advance and clamp in shaving position. As shaving begins, the loader moves back to the magazine to pick up another gear. When shaving is completed, head and tailstocks retract to allow the shaved gear to drop onto unloading rails which carry it out from the machine by gravity.

New electronic device is capable of performing efficiently nearly all the functions of an ordinary vacuum tube yet bears litle resemblance to it. Known as a Transistor the device serves as an amplifier or an oscillator and works on a physi-





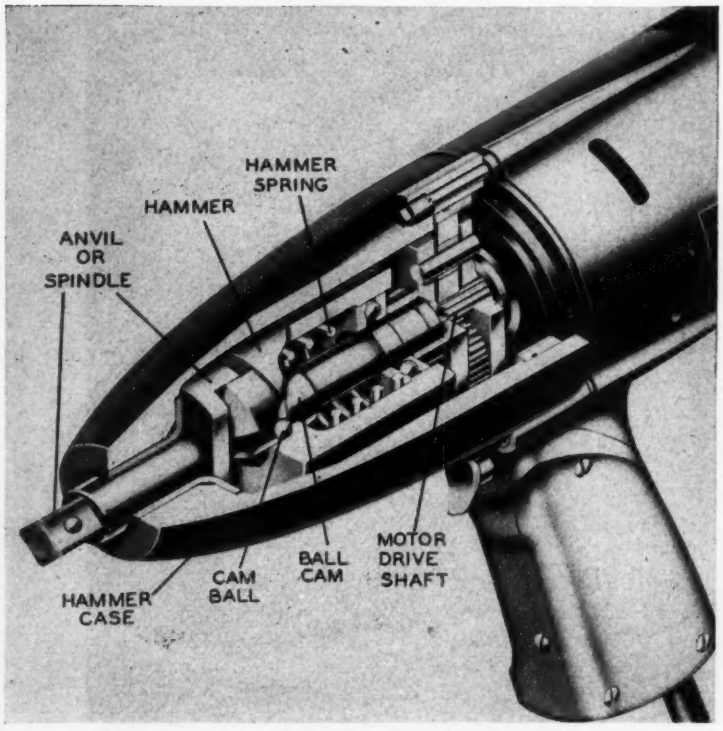
cal principle discovered at Bell Telephone Laboratories in the course of fundamental research into the electrical properties of solids.

Two hair-thin wires touching a pinhead of a solid semiconductive material, soldered to a metal base, are the principal parts of the unit shown above. These are enclosed in a simple, metal cylinder not much larger than a shoelace tip. Tests have shown that the device will amplify at least 100 times (20 decibels). Some test models have been operated as amplifiers at frequencies up to ten million cycles per second, and have been used in radio and telephone equipment.

The two point contacts of the "cat's whisker" or detector type are made to the semiconductor and are only two-thousandths inch apart. Input power delivered to one of these contacts is amplified at least 100-fold and transmitted to the other terminal where it is delivered to an output circuit. The Transistor is energized by an external voltage supply which applies bias voltage to the two points.

Action depends upon the fact that electrons in a semiconductor can carry current in two distinctly different ways. This is because most of the electrons do not contribute to carrying the current at all. Instead they are held in fixed positions and act as a rigid cement to bind together the atoms in a solid. Only if one of these electrons gets out of place, or if another electron is introduced in one of a number of ways, can current be carried. If, on the other hand, one of the electrons normally present in the cement is removed, then the "hole" left behind it can move and thus carry current.

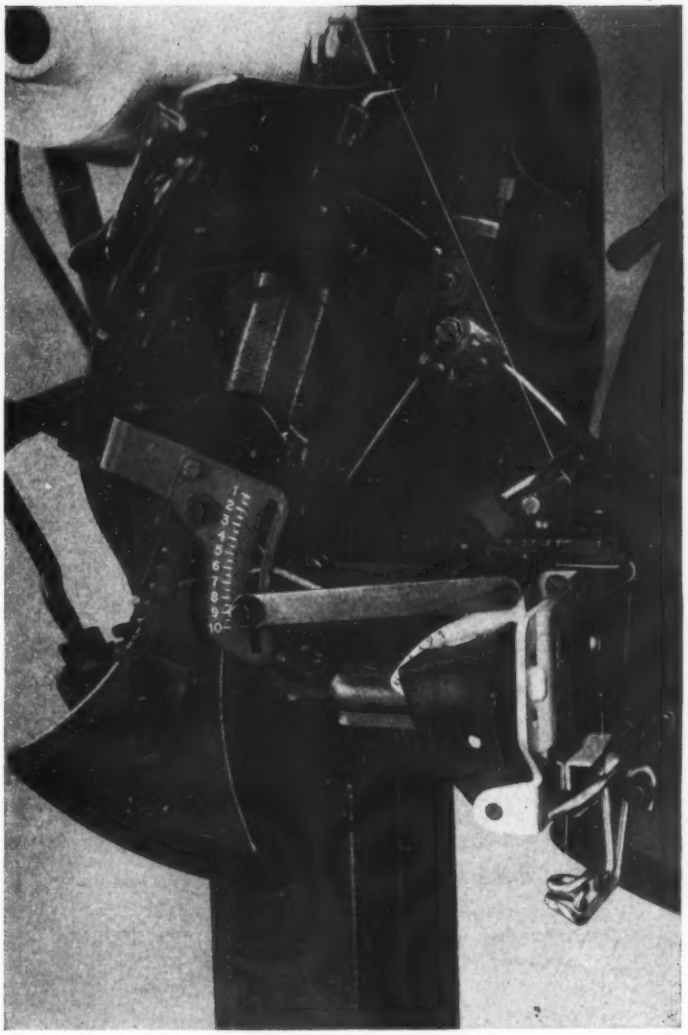
In the Transistor, which normally conducts only by the extra electron process, current flows easily into the input point which is at a low positive voltage and out the output point which is at a higher negative voltage. The area of interaction is produced by "holes" and collected by the output point.



Rotary impacts delivered by the hand tool shown in sectional view at right perform nut running jobs without torque reaction on the operator. With the jaws of the hammer and anvil in contact, the spindle rotates as a unit. When the resistance on the anvil is greater than the initial pressure of the hammer spring, the anvil remains stationary and the rotation of the ball cam causes balls to roll up the cam grooves, pulling the hammer back over the ball cam and compressing the hammer spring. After the hammer is drawn back far enough, the jaws of the anvil and hammer disengage and the hammer jaws slip over the top of the anvil jaws. The power stored in the compressed spring pushes the hammer forward toward its original position with respect to the ball cam. As the cam balls reach the lower part in the cam track, the hammer has attained maximum acceleration and the hammer jaws deliver a rotary impact to the anvil jaws. Nineteen hundred impacts per minute are delivered by this electric tool designed by Ingersoll-Rand Co.

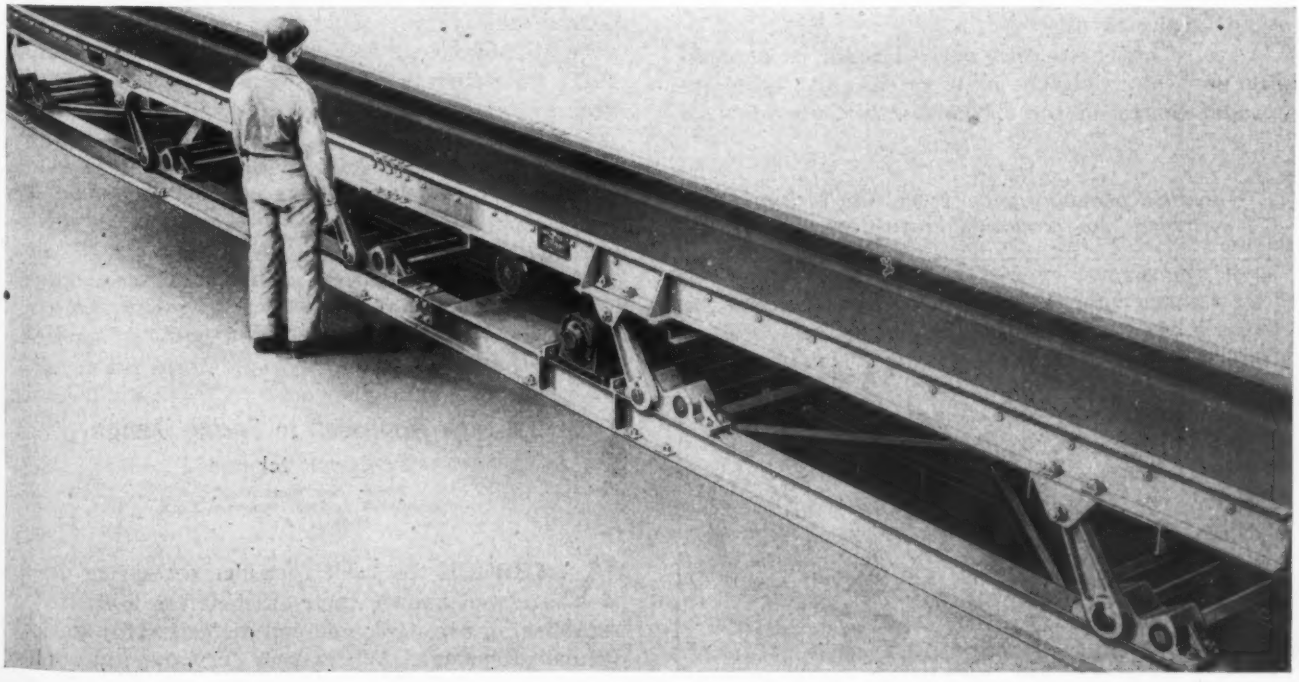
Powered by a universal motor, the tool runs as a conventional electric tool until the going gets

tough. Then the impact mechanism functions automatically and delivers its 1900 impacts per minute. Ease and speed of operation enables the operator to apply or remove studs, tap, and drive or remove screws quickly and with little effort.



Permanent magnet controls the tension on the pinch type device illustrated at right for winding normal twist synthetic yarns. Developed by the Universal Winding Co., the tension device employs a loosely mounted, magnetically attracted tension leaf pressed against a nonmagnetic wear plate by the attraction of a small permanent magnet placed on the back side of the wear plate. Tension on the yarn is determined by the setting of a lever attached to the traverse frame counterweight.

Torsion bars, acting as reactor springs, give improved performance on oscillating feeder-conveyors and simplify construction. The conveyor trough is supported on a series of short arms and adjustable torsion bars as shown in the photograph below. At all points of support throughout the length of the conveyor these torsion bars absorb the energy of trough movement at the end of each stroke, imparting this energy to each return stroke to assist the oscillating drive. Power for the conveyor, which has been designed by Link Belt Co., is supplied by a motor-driven hydraulic coupling through the machines' eccentric shaft and connecting rod assembly.



Design Is Primary Topic at Milwaukee Meeting

MACHINE design topics loomed large at the recent semiannual meeting of the American Society of Mechanical Engineers, in Milwaukee. Twelve papers sponsored by the Machine Design division were presented at five technical sessions, covering such diversified subjects as mechanisms, springs, railroad car couplers, splines, projection welding, lubrication, and induction heating. Brief abstracts of these papers are presented on this and the following pages.

Intermittent Mechanisms

By G. J. Talbourdet

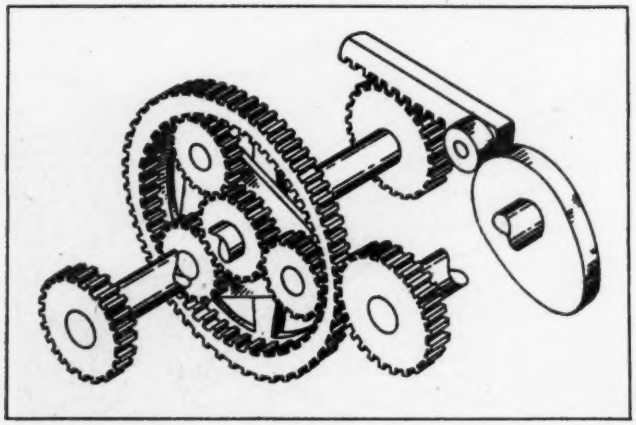
Research Division
United Shoe Machinery Corp.
Beverly, Mass.

IN the field of automatic machinery, many interesting intermittent variable speed mechanisms have been conceived and successfully applied to impart a definite and controlled variable speed to a rotary member. However, most of these ingenious devices are satisfactory only when the speed of operation is relatively low and the inertia of the driven parts is proportionally small.

In many instances such devices could be successfully used at relatively high speeds, and with appreciable inertia of the driven member, provided the forces acting on the driven members are gradually applied and removed during the periods of acceleration and deceleration. To obtain these desirable features, the motion of the driven rotary member should meet the following requirements:

1. Negligible acceleration at the start
2. Gradual change in acceleration
3. Smooth change from acceleration to deceleration
4. Gradual change in deceleration
5. Negligible deceleration as the rotating body comes to rest.

Fig. 1—Internal planetary gear system with rack and cam mechanism for producing intermittent motion



The paper presents a description and analysis of several intermittent variable speed devices in which the features mentioned have been incorporated and proved of real value in the design of turret indexing mechanisms and in many other applications.

In general, these devices are the results of the combination of planetary gear systems, quadric cranks, links and cams in which one of the members of the planetary gear system is driven at a uniform angular velocity, while another is given a controlled oscillatory motion, thus imparting to the driven member a definite and variable angular motion. It is also possible to obtain an appreciable dwell of the output shaft when the oscillatory member of the planetary gear system is actuated by a cam, *Fig.* 1. Furthermore, by the use of such a cam, the output shaft can not only be given a dwell period but also it can be made to reverse its direction of rotation. It all depends on the characteristics of the motion of the oscillatory member of the planetary gear system.

EDITOR'S NOTE: Because of the importance of this paper, it is planned to abstract it more extensively in Data Sheet form in forthcoming issues of MACHINE DESIGN.

A New Approach to Spring Design

By Curt I. Johnson

Engineering Department
International Business Machines Corp.
Endicott, N. Y.

ALTHOUGH the basic formulas for spring design are well known, their efficient use is limited to establishing wire sizes and coil diameters for statically loaded springs. When these formulas are applied

to the solution of spring problems involving dynamically loaded springs which must meet specific requirements with respect to operating loads and spring rate, a laborious trial-and-error procedure is involved. Further complication is added to the problem because, in spite of the fact that such springs require a definite minimum volume of material for satisfactory performance, machine designs are executed often without regard to adequate space requirements for these springs. For this reason, the author began compiling data to provide the designer with more definite reference material on spring design. While investigating these data, several relationships were discovered that resulted in a more straightforward design procedure, eliminating the necessity for numerous assumptions.

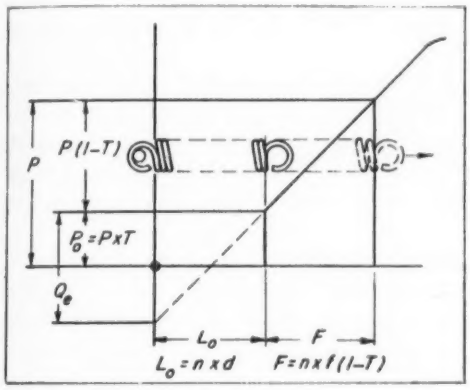
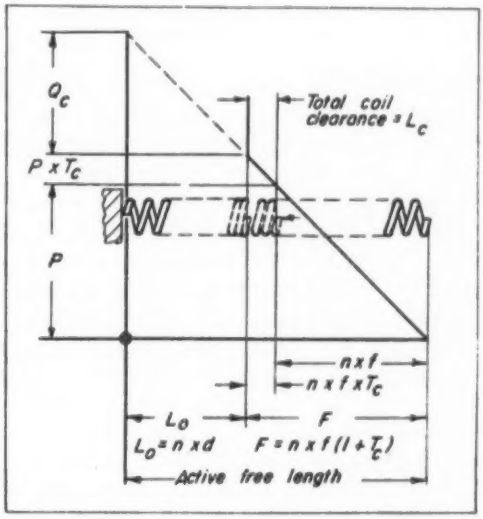


Fig. 2—Left—Graphical representation of extension spring characteristics

Fig. 3—Right—Compression spring characteristics graphically represented



The conventional graphic representation of extension springs has limitations because it does not lend itself to any extensive analysis of the influence of the physical proportions on the operating characteristics. A much more comprehensive picture of the spring proportions and operating characteristics may be had by plotting the applied load versus the extended length of the active coils as in *Fig.* 2.

With this method of presentation, the gradients for springs with varying numbers of active coils will converge at one point as long as the mean coil diameter D, wire diameter d, and initial tension P_0 remain constant. The value represented by Q_e also remains constant for any spring with the same mean coil diameter and wire diameter and is independent of the active length of the spring. Called the load constant, Q may be defined as the theoretical load required to deflect the spring a distance equal to its solid active length, or to produce a deflection in one coil equal to its wire diameter.

Referring to *Fig.* 2, if a load P causes a deflection f in each active coil of the spring

$$\frac{Q}{P(1-T)} = \frac{nd}{nf(1-T)} \quad \ldots\ldots (1)$$

from which

$$Q = Pd/f \quad \ldots\ldots (2)$$

Since stress, or load P, is proportional to strain, or deflection f, it follows from Equation 2 that Pd/f is constant for all springs of the same material, wire diameter, and mean coil diameter.

By substituting $Q = Pd/f$ and spring index $C = D/d$ in the basic equation for spring deflection a formula is derived for calculating the wire diameter:

$$d = \sqrt{\frac{8C^3Q}{G}} \quad \ldots\ldots (3)$$

Values of C and Q are readily obtained from the following two formulas, which are derived in the paper.

These permit d to be determined analytically.

$$Q_c = P(Y - 1 + T) \quad \ldots\ldots (4)$$

and

$$C_c = \sqrt{\frac{GK}{\pi S_c} \times \frac{1}{Y - 1 + T}} \quad \ldots\ldots (5)$$

where Y = deflection ratio = LR/P, and R = spring rate.

A method similar to the one just described for extension springs may be used to analyze graphically the gradients and proportions of compression springs. In this case the active free length of the spring is plotted against the applied compressive load as shown in *Fig.* 3.

The compression spring equations depart somewhat from those derived for extension springs. One reason for this is the fact that compression springs do not have initial tension. Instead they require consideration with respect to coil clearance. By expressing coil clearance as a function of the compressive load P, a coil clearance factor T_c may then be used in the expression PT_c to evaluate the additional load required to cause solid compression L_0 of the spring

from its minimum operating length L.

$$Q_c = P\ (Y - T_c) \quad \ldots\ldots (6)$$

and

$$C_c = \sqrt{\frac{GK}{\pi S_s} \times \frac{1}{Y - T_c}} \quad \ldots\ldots (7)$$

The wire diameter d can then be determined from Equation 2 using values of C and Q from Equations 6 and 7.

Developing the Standard Car Coupler

By Hubert L. Spence

National Malleable & Steel Castings Co.
Cleveland

PROJECTING from each end of every standard-gage railroad car in America is an assembly of some four hundred pounds of steel castings, usually covered with rust, which to the uninitiated appears to be a rather crude looking device. Each of these four million car couplers must be capable of coupling with every other railroad coupler in the country and of operating freely and safely over all track curvature, humps, switches and industrial sidings.

The first concerted effort toward the development and adoption of a single standard coupler began in 1911 when the railroads, through their Master Car Builders' Association, invited the manufacturers of car couplers to join with them in the development of a single standard coupler. Numerous designs were submitted and tested in the laboratory and on the road. Finally two designs survived, of which one, the Experimental Standard D Coupler, became M.C.B. standard in 1916. The weight of the standard coupler was about one-third greater than the former non-standard designs, and its strength one hundred per cent greater.

The various manufacturers of car couplers who had assisted in this development began making the new standard coupler, for which purpose it became necessary to equip each of them with standard construction drawings, gages, and master couplers against which to check the gages. Obviously, the benefits of a single standard coupler would not be attained unless all parts made by each of the manufacturers were completely interchangeable with parts made by all of the others.

The "Mechanical Committee of the Standard Coupler Manufacturers" was organized, consisting of engineering representatives of the manufacturers, and working closely with the Coupler Committee of the Railroad Association. To this Mechanical Committee are referred all matters relating to service troubles and to possible improvements. The committee periodically obtains couplers from each manufacturer, checks them for interchangeability of parts and tests them for strength. All recommendations of the Mechanical Committee are submitted to the Coupler Committee of the Railroad Association for approval and if necessary for submission to letter ballot of the Association. An official set of construction drawings of the standard coupler and of the gages is on file with the Railroad Association, and the manufacturers of standard couplers have no authority whatever to change the drawings or to depart in any way from the standard design.

Standard gages for all coupler parts and a specification for the purchase of standard couplers were adopted by the Railroad Association. This specification sets limiting weights for each coupler part in addition to controlling the properties of the steel from which each part is made.

The standard coupler is of the type employing a hook-shaped knuckle rotating on a vertical pin, *Fig.* 4. As two couplers come together with one or both knuckles open, the head of one coupler contacts the open knuckle of the other and closes it. When that knuckle reaches the closed position a gravity-actuated lock drops in front of the tail of the knuckle and locks the coupler.

In the years following its adoption, numerous adjustments and improvements were approved by the Coupler Committee or by letter ballot. These changes, for the most part, related to wearing points and were for the purpose of increasing the wear life of the coupler.

Train tonnage and locomotive power increased steadily during this period and it was ultimately felt that the standard coupler should be strengthened in keeping with the more severe service demands. Other mechanical improvements were found possible but would affect interchangeability of parts. The A.A.R. Committee on Couplers and Draft Gears in co-operation with the Mechanical Committee of the Standard Coupler Manufacturers, in 1930, offered the Association the Type E Coupler. This became A.A.R. Standard in 1931, completely superseding the D Coupler.

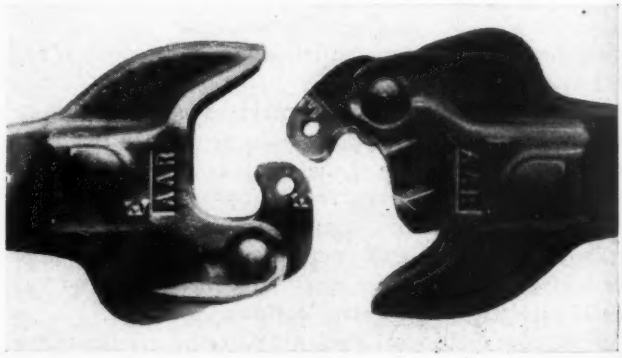


Fig. 4—Standard E type railroad car coupler elements just prior to engagement

The Standard E Coupler weighs 10 per cent more than the former standard. The elastic limit strength of its knuckle is 28 per cent higher than the D knuckle and the ultimate strength of the coupler body is 12 per cent higher.

The main repair part of a coupler is the knuckle. The Standard E Coupler is so designed that its knuckle can be used in D Couplers for repairs, thus giving those couplers the benefit of the new stronger knuckle and the improved positioning of the lock.

It is also possible to use D knuckles in E Couplers, the lock even under those conditions assuming the improved seating position. The undesired application of other D Couplers is prevented by the intentional design of the Standard E Coupler.

Assembly of the standard coupler is a one-man job provided the parts are assembled correctly. The only part which can be omitted without making the coupler completely and obviously inoperative is the knuckle thrower. Without that part the lock will not allow the application of the one hundred pound knuckle except with the assistance of a helper to hold up the lock manually. This serves as an adequate warning that the coupler is being improperly assembled. The application of the knuckle pin and insertion of a cotter through the pin completes the assembly. It is then impossible to remove any part without first removing the cotter.

Maintaining Strict Interchangeability

The coupler is manufactured by five steel foundries in the United States and two in Canada. To maintain strict interchangeability between the parts made by these seven plants requires very complete and rigid gage control of all parts. Thirty-four Class I gages control the coupler head and parts; fifteen more Class I gages control the standard and alternate standard shanks and eight Class II gages are used for periodic checking of coupler heads and shanks.

All Class I gages are used on one hundred per cent of production. Each manufacturer has a complete master coupler with hardened inserts or hardened surfaces at each gaging point. The gages are periodically checked upon these masters.

No gage wear limits have been officially established, but from long experience the coupler manufacturers have determined very closely the amount of allowable gage wear which can be tolerated without affecting the functioning of the part or its interchangeability.

All gages are initially fitted to the master coupler and must not depart from the master by more than 0.002-inch. Most of the gages are steel castings fitted with hardened steel inserts at the gaging points and hard chrome-plated at the points of maximum wear. A set of working gages costs approximately $10,000, and one set of production patterns and coreboxes at the present time is worth $20,000. Each plant has six or eight such sets of patterns and coreboxes.

As of July 1, 1947, all standard coupler knuckles and locks are high tensile steel. In addition to the increased strength, these parts offer a longer wear life. The knuckle is purposely designed to be somewhat weaker than the body of the coupler or the coupler attachments. The knuckle thus serves as a "safety valve" to protect the more expensive and less readily replaceable parts of the draft system.

During the early nineteen-thirties certain of the manufacturers of the standard coupler began the development of various forms of tightlock or interlocking couplers for passenger train service. The aims of these developments were two-fold; to reduce to the absolute practical minimum the amount of free slack in the draft system in order to improve train riding conditions, and secondly, to secure certain additional safety features.

A tightlock coupler must of course be able to couple and operate safely with the Standard E Coupler and with the various nonstandard designs still found on passenger cars. The practically complete elimination of slack required machine finishing of several surfaces so that a pair of couplers interlock together with an almost line-for-line fit. The tight fitting of these couplers requires a different arrangement of the internal operating parts from that of the Standard E Coupler. The A.A.R. Tightlock Coupler parts are purposely so designed as to prevent their use in Standard E Couplers and the head is so designed that E Coupler parts cannot be assembled in the A.A.R. Tightlock Coupler. The only exceptions are the knuckle pivot pin and cotter and the support pin and its cotter, which are common to D, E, and Tightlock Couplers.

Practically all passenger cars built during the past six or eight years have been equipped with Tightlock Couplers, and many old cars have been converted. The Association of American Railroads, by letter ballot in 1946, adopted this as the A.A.R. Standard H Tightlock Coupler.

The design of car couplers has developed largely by the cut-and-try method. No one has ever evaluated the forces acting upon the coupler. The A.A.R. Standard E Coupler for freight service and the A.A.R. Standard H Tightlock Coupler for passenger equipment service represent the results of over thirty years close engineering co-operation between competitive manufacturers and their customers, the railroads of America.

Straight-Sided Splines

By J. B. Armitage

Vice Pres. in charge of Engineering
Kearney & Trecker Corp.
Milwaukee

IN the early days of the automobile, the Society of Automotive Engineers developed a standard for multiple spline fittings having 4, 6, 10 and 16 splines. This standard has formed the basis quite generally for multiple splined shafts and fittings used in industry but various companies have made certain modifications.

A few years ago, a committee of the American Standards Association was appointed to formulate a standard to adapt the SAE standard for the use of machine tool and general machinery manufacturers. It was decided to base the new tentative standard on the outside shaft diameter as the nominal diameter and to confine the standard to only one key height, the height designated to "slide when not under load" in the SAE standard.

There can be three *types* of fit between the shaft and fitting—on the minor diameter, on the sides of the keys, or on the major diameter, *Fig.* 5, and five *classes* of fit for each type. The five *classes* of fit are (1) free fit, (2) sliding fit, (3) push fit, (4) light drive fit, and (5) press fit. Experience indicates that these five classes of fit are necessary to meet all the

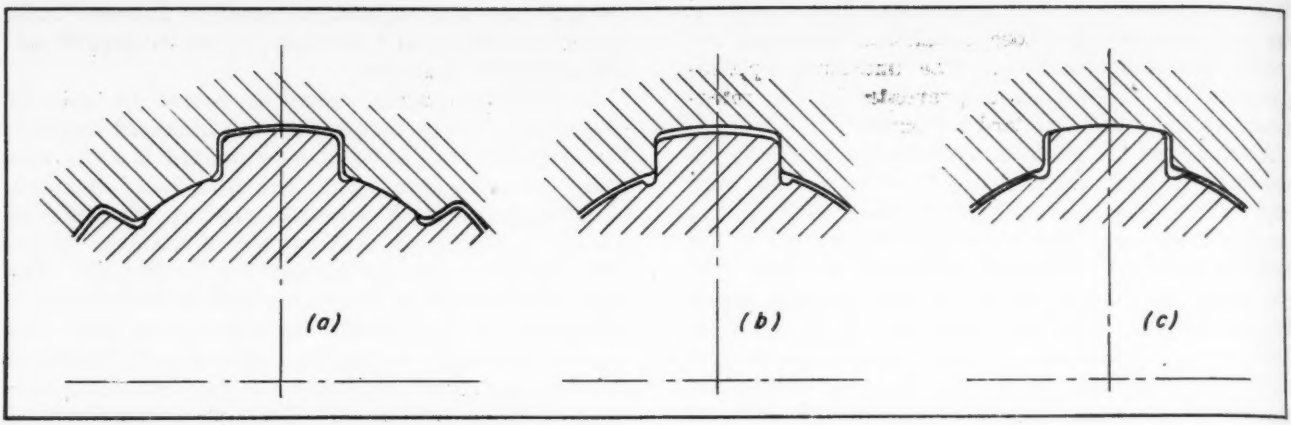


Fig. 5—The three types of fit for spline fittings: (a) on minor diameter; (b) on sides of keys; and (c) on major diameter

major requirements of general machine design as follows:

1. Free fit is desirable for long shafts where the sliding member is supported independently of the shaft—where the shaft transmits torque alone
2. Sliding fits may be used for such elements as sliding gears, clutches, etc.
3. Push fit is used for parts which must be taken apart after assembly
4. Light drive fit is suitable for parts which are disassembled only in case of breakage or major maintenance
5. Press fit is used for the permanent assembly of solid shafts to parts with heavy hubs.

The 4-spline fittings of the SAE standard have seldom been used in machine tool or general machinery design and for this reason have been dropped from the new tentative standard. It is intended to use only the 6, 10, and 16 spline fittings with diameters from ¾-in. to 6 in. Shaft sizes will vary in increments of ⅛-in. from ¾-in. to 2 in. nominal diameter, increments of ¼-in. from 2 in. to 4 in. and in ½-in. increments from 4 in. to 6 in.

It is the author's opinion that with the successful introduction of the involute spline standard, the straight-sided spline should and probably will be used less and less. However, where parts must be hardened and cannot be machined except by grinding after hardening, the minor diameter fit straight side spline offers definite advantages.

Involute Spline Experience

By Charles H. Stanard

Buick Motor Division
General Motors Corp.
Flint, Mich.

EXPERIENCE with the involute spline has brought out practices that seem advisable to use in production and some that should be avoided. Reasoning behind the use of the major diameter for location, both for machining and functioning, is based upon the observation that the internal teeth change less than the external teeth. The major diameter is not corrupted by error of contour, spacing or lead. Contacts here cannot upset the teeth as can happen on minor diameter fits. When broaches are used, the major diameter can be held to tenths of thousandths throughout the life of the broach. The greatest area of contact is immediately available in a major diameter fit and fretting is reduced. Two installations on the same power line have been under observation for some time, one member being a light press fit on the major diameter, clamped between a nut and bearing. This spline is one-half the length of the other, which is a press fit on spline tooth sides and fixed against movement by a cross pin. The fretting of the short spline is hardly discernible while the other is always badly fretted.

A design to be avoided, whenever possible on a hardened fitting, is that of a short thin-sectioned hub adjacent to a larger gear or flange body. Constant checking shows that the broaches force out the metal of the hub, producing a slight taper in the soft state. When hardened, this section may close up to 0.0035-inch within a 1¼-inch diameter. If such a tapered condition is used between a shaft and member, not fastened together, end forces may be produced far exceeding any expected bearing or pedestal calculations. This is a common error and one that results in bearing failure under loads that forces attention on material failure when it is actually dynamic loading. Original material condition is a debatable question on a badly burned and scored bearing.

Much has been said about the effects of surface smoothness on the ease of shifting between splines. Observation has shown that rarely ever is it possible for the operator to tell smoothness of spline surface by shifting. So-called rough splines will provide oil pools and give perfect lubrication for shifting, while a too smooth ground surface will allow the oil to be pushed out under pressure, resulting in galling when moved.

Broaching Spline Shafts and Fittings

By Harry H. Gotberg

Chief Engineer
Colonial Broach Co.
Detroit

IN designing any type of spline, it should be emphasized that the tools required should always be considered in the actual product design. Product design can sometimes be altered slightly to facilitate tooling without interfering with the functional requirements, thereby insuring a great saving in tool-

ing costs as well as in maintenance.

The new American Involute Spline Standards serve as a good example of this. Its adoption has reduced greatly the number of hobs required to produce the various splines involved. Similarly, even though it is almost mandatory that broaches be "custom" made to conform to individual-part print specifications, a standard spline system also has many tooling advantages in regard to broaches.

It should be understood that the cost of a spline broach depends primarily on its diameter and over-all length, although other elements, such as the number of splines and the depth of the splines, also enter in the cost of the broach. Length of the broaching tool is determined primarily by the depth of the spline to be cut, the length of the part, and the type of material to be broached. From these, engineers can usually calculate the torque load and other elements of spline strength. Allowing a practical safety factor, this means that the length of the spline part and the depth of spline can easily be held to a safe minimum, reflected automatically in minimum tooling costs without jeopardizing the strength of the component parts.

Since the depth of the spline exerts a major influence on broach length, the new American Involute Spline Standards were based upon a stub tooth form. This tooth form reduces required depth of broach cut, thereby reducing the over-all length of broach, as compared to the length of broach required for a full-depth involute form.

Reducing Wear on Broach

In designing the new standards, another factor influencing broach costs has also been taken into consideration. The corners of splines have a tendency to subject a broach to greater wear and breakdown than does the body of the tooth, especially when it is necessary to hold corners to a sharp point. As a result, where relatively close tolerances have to be held on major diameters, difficulty is sometimes encountered in assembly owing to the breakdown of spline corners, even though the difference may be only a little more than a few thousandths of an inch. This condition sometimes occurs even after relatively few parts have been broached.

In order to avoid this condition, the splines in the new standards have been provided with adequate radii on the top of the splines, the component spline shafts being chamfered to correspond to these radii. This provision not only insures facility of assembly of splined parts but also increases broach life materially.

Another important tooling factor in favor of the recommended standards for involute splines is the advantage of reducing costs in the processing of broaches for experimental designs of products. It is well known that involute-spline broaches are high-precision tools and accordingly are rather costly to produce. Usually the cost of such broaches for experimental purposes tends to be prohibitive, especially where only two or three experimental parts are required. From past experience, we know that it is almost impossible to locate standard broaches of the exact specifications desired for the experimental purposes in mind. In contrast to this, once these new involute-spline standards have been generally adopted, and the broaching tools for them standardized, it will be possible to secure a broach with the exact specifications desired from some other source already using the same tool in production.

Hobs for Spline Shafts

By Anthony F. Zamis
Chief Design Engineer
Illinois Tool Works
Chicago

POPULARITY of the parallel key type of spline is not due to its adaptability to the hobbing process. The hobbing of this work is, in fact, susceptible to more problems and difficulties than are encountered by almost any other class of work commonly produced by the hobbing process. For example, the hob itself is more difficult to produce because its tooth profile is not a sraight line but an irregular curve. Both the manufacturing and inspection phases are impeded by this fact. The user of this tool is likewise handicapped by his inability to inspect its profile.

None of these and other difficulties are encountered in hobbing involute splines with 30 degrees pressure angle. The straight line profile on the hob tooth is easy to manufacture and to inspect. The cutting clearance on the side of the hob tooth is uniform from top to bottom and is easy to acquire by virtue of the 30-degree pressure angle. This fillet at the root of the keys can be entirely eliminated, if desired, by establishing the generating pitch line on the root diameter of the shaft.

Hobs for 30-degree pressure angle involute spline keys have only one cutting characteristic less desirable than those for parallel spline keys. The 30-degree pressure angle transfers a greater component of any radial displacement of the hob to the profile of the spline keys. The accuracy of the cut profile, therefore, will suffer more from the effects of eccentricity in the sharpening of the hobs or in their mounting. In practice this does not prove to be a major problem. Experience has shown the overall accuracy on involute spline keys to be much greater than that found on the parallel spline keys.

Appreciating the almost universal application of the hobbing process in the production of spline shafts, the editors of the new American Standard Involute Spline have evolved a spline system whose adaptation to hobbing has been given every consideration. An important example of this consideration is seen in the specification given for root fillets. These fillets are consistent with the root clearances allowed and permit a corner radius on the tip of the hobbed tooth. This feature greatly lengthens the overall life of the hob.

One of the most far-reaching results of their efforts on the behalf of the hob users is the small number of hobs required to cut all the shafts within the framework of the standard. The significance of the achievement in this respect will be appreciated when we look at a single page of the Standard on which are defined three hundred and ninety-six different

spline shafts, representing forty-four different numbers of teeth, three classes of fits, and three types of fits, all of which may be cut with a single hob.

As the involute spline is more widely substituted for the conventional parallel key spline, the hobbing process will be thought of as not only the most efficient method for producing spline shafts, but a very satisfactory and trouble-proof one as well.

Projection Welding of Fasteners

By Robert A. Reich
Chief Engineer
The Ohio Nut & Bolt Co.
Berea, O.

PROJECTION welding is a method of resistance welding whereby the current flow and heating during the welding operation are localized at predetermined points called "projections" or "embossments". When determining whether a job should be projection welded the following factors should be considered:

1. The materials used must be suitable for projection welding
2. The work to be welded must be so designed and of such a size as to enable it to be carried to the welder
3. The quantity must be large enough to warrant the cost of tooling up
4. Suitable welding equipment must be available.

It is particularly important to consider fastener applications before starting the layout on any new or original design. Many times the designer may make a slight change in a design to accommodate a standard fastener while the job is still on the board. In some cases it has been necessary to redesign a complete product and even have stamping or forming dies rebuilt in order to use a certain fastener. If proper thought had been given the problem at the start of the layout all this unnecessary expense could have been avoided.

When a design includes fasteners which are to be projection welded it is important to set up the correct material specifications. Many materials may be suitable for projection welding but are different or impossible to upset and coldwork. The following materials are well suited in both respects: Low carbon steel (carbon 0.20 per cent max.); naval brass; monel, and stainless steel (18-8).

In respect to finish specifications on fasteners, the optimum welds are always made on products furnished in bright finish. Bright finish means a clean surface without scale or other foreign materials, such as platings, etc. Quite often a completed assembly may be too large to place economically in which case it is much better to have the fastener and sheet plated before they are welded. Zinc (electro-galvanizing) is the best plating and does not materially affect the welding operation and good, strong welds can be obtained.

Weld products should never be specified with Parkerized or Black Oil finish (Annealed finish) as these finishes are very poor conductors of electricity, and if used it would be necessary to burn through the finish on the first impulse and do the actual welding on the succeeding impulses. In cases of this type it would be necessary to use a pulsating timer which automatically controls the number of impulses and cycles during the "on" and "off" periods.

When presenting a problem to a fastener manufacturer there are three important factors which must be decided upon:

1. Thickness of sheet metal to which fastener is to be welded
2. Type or analysis of material to be used
3. All important or limiting dimensions must be given.

Whenever possible, an integral projection is recommended. The embossed projection is used for many sheet metal fasteners but the embossing leaves a weak section in the parent metal adjacent to the projection. During the welding operation the projection has a tendency to collapse and flow back into the sheet.

There are many types of projections, all of which will result in good welds if the right projection is used for the job. *Fig.* 6 illustrates the most commonly used projections for fasteners. Three projections provide a "three-point bearing" and should be specified whenever possible. In cases where it is impossible to use three projections, it is much better to have one or two than a number exceeding three. If more than three projections are used it is difficult to obtain uniform electrical contact on all the projections, consequently some of the projections will not be welded and the resulting strength of the total welded area, in some cases, may be only 50 per cent of the estimated strength.

Rib, single spherical and cone projections are used when welding to stock over 0.093-in. thick, the other projections are used for welding to stock under 0.093-in. thick. Ring-type projections are used when water or gastight welds are required. The ring projection is ideally suited for sealed welds but requires good welding equipment. A press-type welder with modern electronic controls is essential.

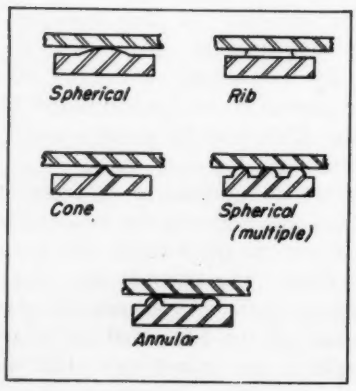


Fig. 6—Five of the most commonly used projections for projection-welded fasteners

Studying Lubrication

By John Boyd
Westinghouse Research Laboratories
East Pittsburgh, Pa.

OVERSIMPLIFICATION of a problem often obscures the real nature of the actual phenomena involved. Thus the journal bearing, prior to the time

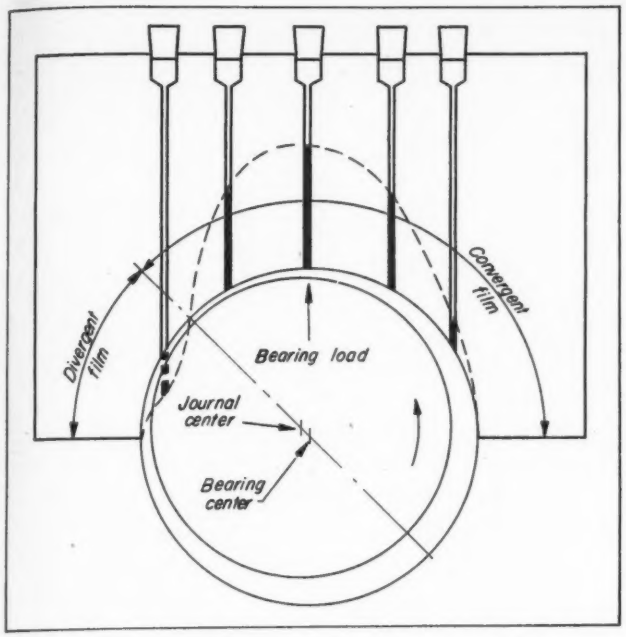


Fig. 7—Pressure distribution in the oil film of a 180-degree journal bearing obtained on model

of Reynolds, was considered to be nothing more than a shaft in a hole. As a result, many of its characteristics of operation could not be explained.

As an aid in demonstrating some of the principles of hydrodynamic lubrication, and as a help in giving added meaning to the analysis, simple transparent models may be used. One of their advantages is that they permit observation of the lubricating film and detection of discontinuities and differences in thickness by variations in film color. Transparency also permits the path of the lubricant to be traced through the bearing by introducing filaments of dye into the oil film.

A further advantage is that, by providing small holes at different points, the pressure of the film at each of these points will be indicated by the height to which the lubricant rises in the holes.

This paper describes the construction and operation of simple slider- and journal-bearing models, by means of which it is possible to show the pressure developed in an "oil wedge," the position of the maximum pressure, the effect of speed, viscosity, and so forth.

Another use to which transparent models may be put is the determination of the extent to which the idealized conditions used in analyses are borne out in practice. Most analyses assume the bearing to be supplied with a full fluid film. Practically this is not always the case, as may readily be seen from a model study. The models are particularly useful in determining the effectiveness of grooves, reliefs, and the like.

The journal bearing model consists of an aluminum journal which may be rotated by hand and a 180-degree bearing which rests on the top of the journal in a mannner similar to a railway-axle bearing. Attached to the bottom of the bearing are four rods supporting the oil reservoir and a steel counterweight. The reservoir may be adjusted vertically to bring the oil in contact with the under surface of the journal. The counterweight serves to provide a load for the bearing and as a pendulum weight to produce a restoring moment when friction tends to rotate the bearing.

When oil is placed in the reservoir and the journal turned over for the first time, the bearing will start under dry-friction conditions since the oil will not be carried to the sliding surfaces until the journal has made about one-half of a revolution. If the journal is turned very slowly, the film formed will be rather imperfect but the coefficient of friction will be found to decrease. As the speed of rotation is increased, the coefficient will fall almost to zero and the oil will rise in the holes as shown in *Fig.* 7. The presence of a region of negative pressure can be demonstrated by removing the end stopper so that air may be drawn into the film.

Cores in Die Casting Design

By C. R. Maxon
The New Jersey Z.nc Co.
New York

BOTH the value and general utility of die castings are greatly enhanced by the facility and precision with which coring can be done. This is evident when the following advantages of coring are stated:

1. Substantial savings in the weight of the casting
2. Provision of holes and recesses within close limits as to size and location
3. Uniform sections
4. Sound castings
5. Shorter casting cycle, resulting from faster cooling
6. Decreased machining time and cost.

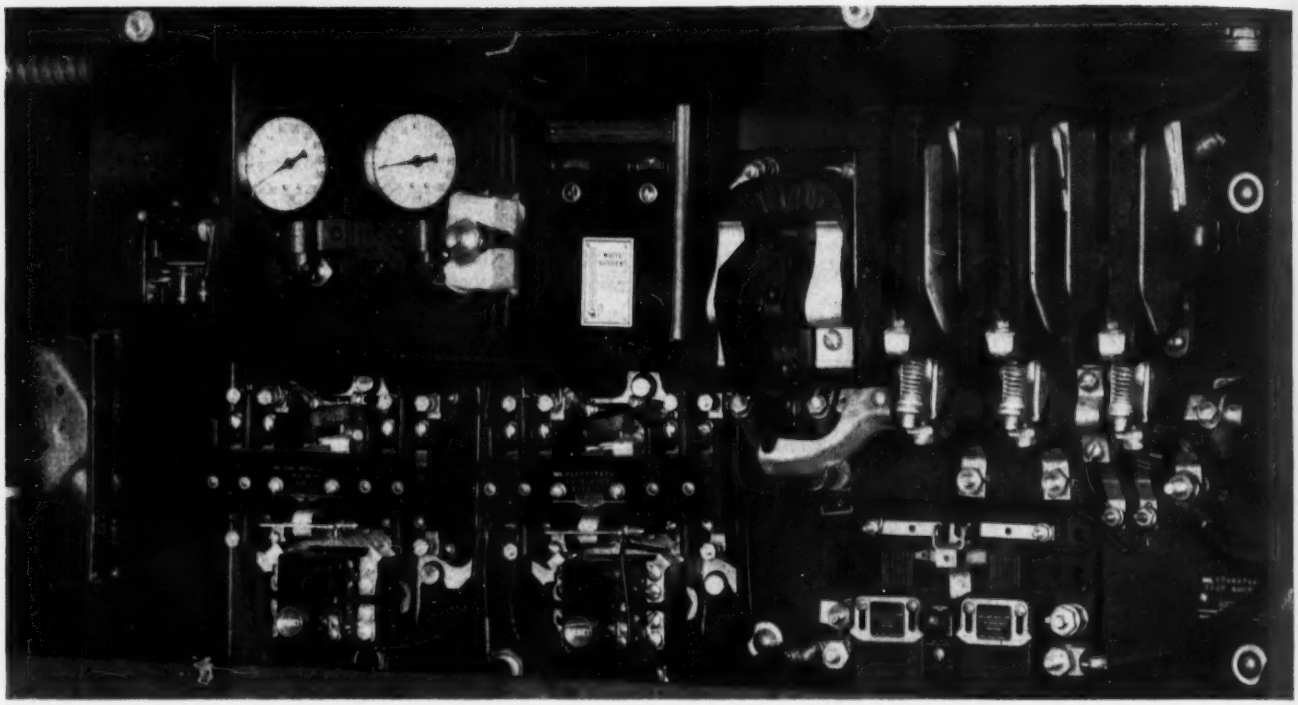
Several of these advantages are not attained at all or only in much more limited degree in sand castings and are partly responsible in most cases for making die castings less costly than the nearest sand-cast equivalent. For sand castings, the core must usually be made separately and placed in the mold, and the mold is always destroyed after the casting is produced. It is difficult to hold close dimensions with sand cores, and they often shift in the mold so that the hole or recess is not correctly located.

In contrast, the cores for die castings often have a life as long as that of the die itself. Moreover, their size is subject to little or no change, hence the hole or recess formed is held closely to size and changes in location are slight. Naturally, this greatly reduces and frequently eliminates machine work on the hole or recess.

In addition, many holes that are readily cored in die castings are too small in size to be cored at all in sand castings. In die castings, cored holes are precisely located and often can be held to tapping size. In occasional instances, a threaded core can be used and then even tapping is avoided.

There are of course many cases in which small holes needed in die castings cannot be cored as cheaply as they can be drilled or pierced, but even a conical spotting core often can be used to locate the

(*Continued on Page* 176)



Relay Prevents Short Cycling

By Warren Ewald
Design Engineer
United States Air Conditioning Corp.
Minneapolis

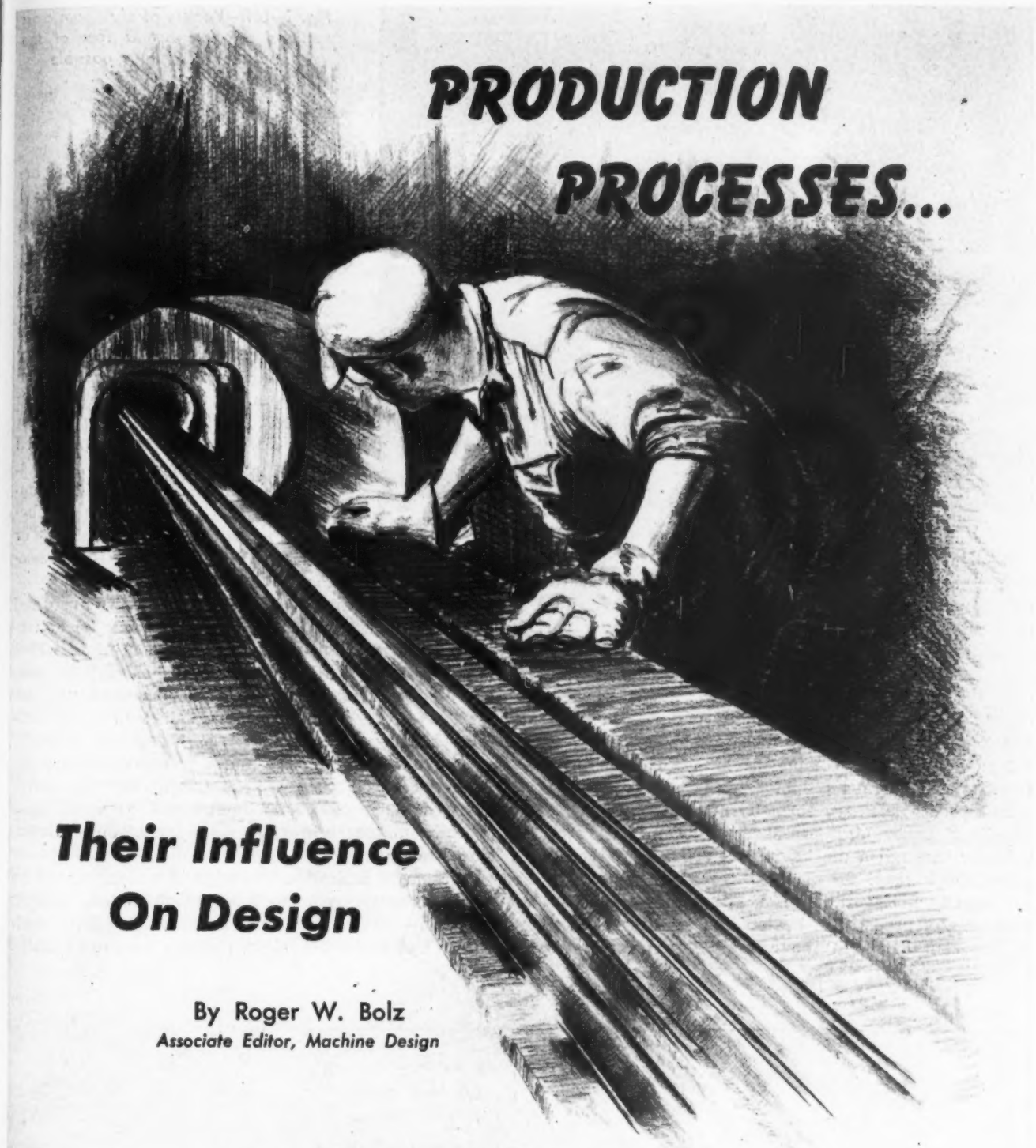
AUTOMATIC control system for air conditioning units has been improved recently by the addition of a relay to prevent "short cycling" due to suction pressure build-up. These units are powered by three motors, a large one for driving the compressor, one smaller motor for driving the blowers moving the conditioned air and a second small one for driving both the blower and the water pump of the evaporative condenser. Each of these motors has a magnetic type of starter which includes overload protection with reset buttons. The conditioned air blower motor may be operated independently but this motor must be in operation before the compressor and condenser motors may start.

Primary control is by an electric thermostat located either in the conditioned space or exposed to the return air. This thermostat controls the circuit actuating a solenoid valve in the liquid line of the unit refrigeration system, which valve, in combination with a thermostatic expansion valve, governs the flow of refrigerant to the evaporator coil of the refrigerating unit.

When the thermostat causes a flow of refrigerant into the evaporator coil, an increase in pressure occurs in the suction line from this coil. This pressure, through the Hi-Lo switch, actuates the motor starters for the compressor and the evaporative condenser and these motors continue in operation until the suction pressure is lower than the swith setting. They will stop if the compressor and condenser should pump and condense the refrigerant faster than the evaporator converts the liquid to gas.

When the thermostat cuts off the supply of refrigerant to the evaporator, the compressor will continue in operation until it reduces the suction pressure to the switch setting. This is called a "pump down," and the compressor should then remain shut down until more cooling is required. However, if the suction pressure rises, due to leakage back through the compressor or from refrigerant evaporation from oil, then short cycling occurs.

To prevent this objectionable restarting, when cooling is not required, a relay switch is placed in the electrical circuit of the Hi-Lo and motor starters. This relay is actuated by the thermostat-solenoid circuit and is closed only when the thermostat calls for cooling. Thus the thermostat has veto power over the Hi-Lo control. This control scheme, on which a patent is pending, will avoid the annoyance, electrical cost, and wear from useless short cycling.



Their Influence On Design

By Roger W. Bolz
Associate Editor, Machine Design

Part XXXVI–Hot Extrusion of Metals

Direct extrusion of metals in simple, symmetrical forms had its beginning years ago with soft, workable metals such as lead, tin, zinc, lead-tin alloys, etc. Cable sheathings, hose casings, lead pipe, wire, and similar relatively simple cross-sectional forms comprised the major production. During the intervening period of development leading to the perfection of today's modern die steels the range of metals which could be handled moved into the field of metals having higher strength and requiring higher extrusion temperatures. As the processing technique improved it released the process from the narrow confines of simple, symmetrical sections and today shapes of almost unlimited variety can be readily produced in a wide selection of engineering alloys, *Fig.* 1.

Offering in essence a "partial fabrica-

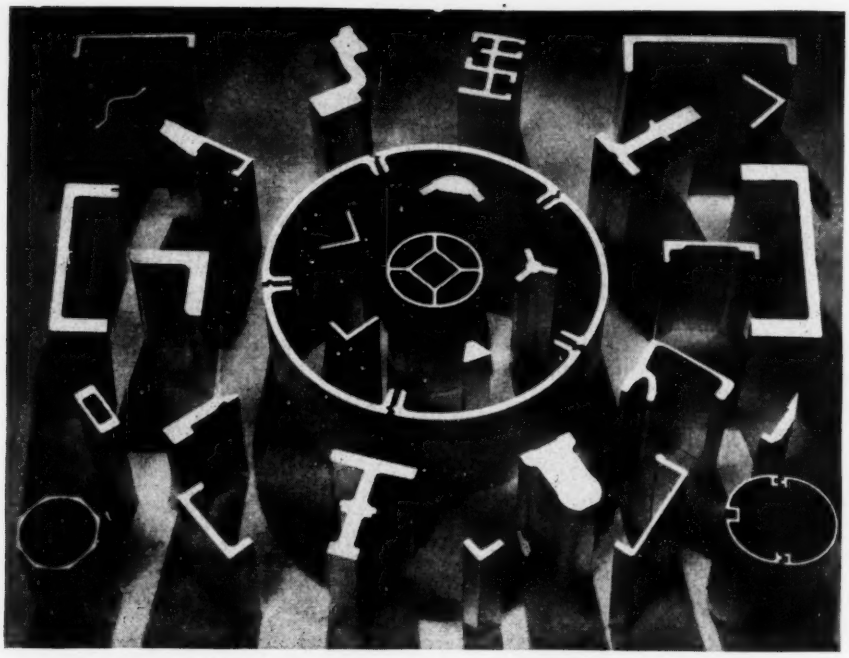


Fig. 1—Left—Variety of aluminum cross sections showing but a few of the thousands of shapes possible

tion", the direct extrusion process commands its rightful niche in the panel of important production processing methods. Thorough application of the principles of designing for economical production makes it highly desirable that the advantages available through the use of extruded shapes be kept closely in mind. Conservation of valuable material and reduction in processing operations necessary to complete a unit or component makes it imperative from an economical standpoint.

Extruded shapes are normally produced by forcibly expelling, under high pressure, a hot plastic metal cylinder through a die having an opening of the desired shape, *Fig.* 2. Presses for these operations are usually horizontal, *Fig.* 3, although verticals are occasionally used. The heated metal billet is placed in the container and the hydraulic ram forces the metal to flow through the die arrangement, emerging in solidified form closely conforming to the dimensions of the die opening.

The natural field of application for extruded shapes lies with the possibility of eliminating costly or difficult machining operations. Any part or component which may have an irregular cross section, the surfaces of which can be planes parallel to the longitudinal part axis can be economically produced from multiple-length bars, *Fig.* 4. The few necessary finishing operations can be handled on production machines either before or after sawing or cutting to the necessary length for the part being made.

Further advantages of extruded shapes over and above possible production economies may be attributed to physical properties of the materials which can be extruded. Some of these considerations are: (1) Excellent machinability for subsequent processing; (2) electrical or thermal conductivity; (3) uniform density of structure; (4) acceptable surfaces without machining; (5) greater tensile strength; (6) improved ductility; (7) good toughness; (8) corrosion resistance; (9) hard surfaces; (10) metal color or color match; and (11) closely controlled dimensional tolerances.

The major limitation to design in making use of an extruded shape basic stock is that of section. Shapes must have a constant cross section throughout their length and any holes, slots, grooves, etc., not parallel

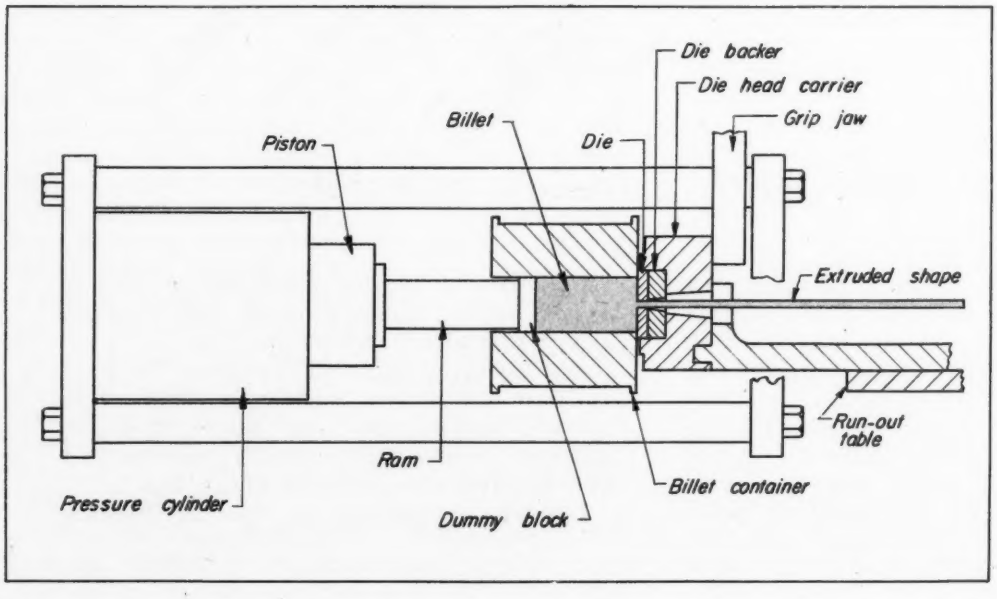


Fig. 2—Left — Sectional view showing the general setup used for direct extrusion of metals

to the axis of the part in mind must be produced by machining or some other subsequent operation. Capacity of existing equipment further limits the size of shapes which may be extruded; present maximum size of shapes in aluminum is about 12½ square inches and the shape must fit within a 10-inch circumscribed circle. Length is limited to 50 feet and weight to 350 pounds. Section size limit for copper and copper-base alloys is roughly one-half that for aluminum.

Shape design in extrusions is practically unlimited. The designer is not restricted to accepting a substitute standard shape. Special sections exactly suited to a particular design can be readily obtained. Wall thickness throughout a section need not be uniform as with rolled shapes. Within broad limits metal may be placed as desired for strength or stiffness, or to obtain complicated contours which defy economical machining. Die cost is relatively small, dies for simple shapes starting at a minimum of about 60 dollars. Processing operations are extremely flexible and short runs can be made economically as well as long runs.

DIES: Direct hot extrusion requires die steels which exhibit the maximum hot hardness and strength for economical production. The "lead-in" or bell mouth on a die for copper and copper-base alloys is on the entry side, and the bearing is on the exit side. For aluminum, zinc and magnesium, however, the bearing is at the entry side and corners are as sharp as possible with the exit side being relieved to allow for expansion of the metal as it emerges.

Aluminum and magnesium alloys are extruded as hollow shapes by using so-called "spider-web" or porthole dies wherein the metal is parted in passing over the webs supporting the center plug or mandrel and again self-welded before leaving the die exit. Copper and its alloys do not bond or weld in this manner and so are seldom produced as hollow shapes.

No rules or set mechanics govern the design of shape dies. Die production depends mainly upon

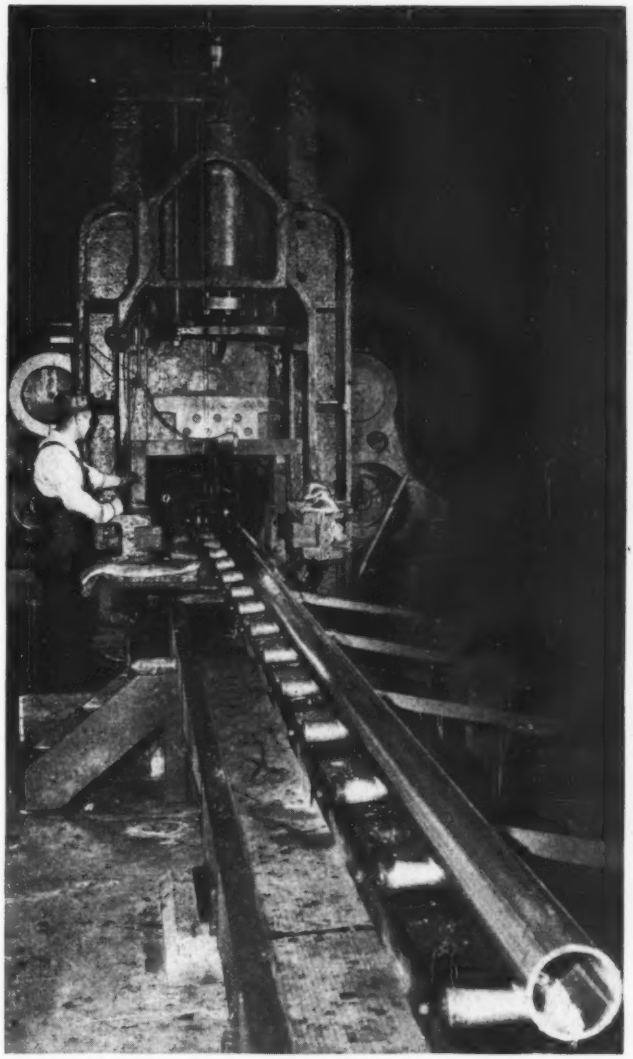


Fig. 3—Above—Typical extruding press in operation producing plain magnesium tubing

Fig. 4—Below—Sketch showing a variety of machine parts which are produced most economically in quantity from multiple length extruded shapes

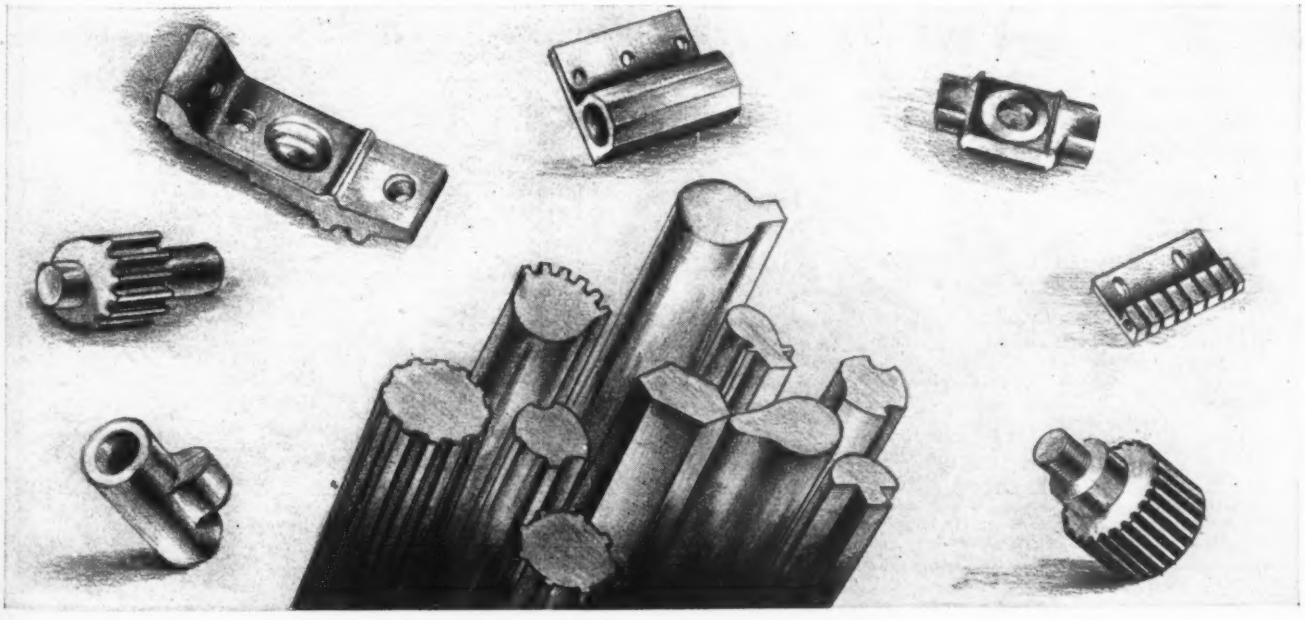


TABLE I—Commercial Extrusions and their Characteristics

		Composition										Characteristics*		Extrudability (in order of relative ease of extrusion)
	Alloy	Cu	Si	Mn	Mg	Zn	Ni	Cr	Pb	Al	Other	Applications	Design	
1	Copper	99.9	..	..	..	..	..	..	..	..	..	Electrical parts. Machinability 20%	Heavy sections, wide variety of shapes, min. gauge ⅛-in. av. Ext'd & drawn only	C
2	Copper (Free cutting)	Rem.	..	..	..	..	..	..	..	..	0.5Te	Electrical parts. Machinability 60%	Same as for Copper #1	C
3	Yellow Brass	62.0	..	..	..	Rem.	..	..	1.5	..	..	For moderate to severe bending and flaring. Machinability 40%	Simple sections. Min. gauge $\frac{3}{16}$-in. desirable. Ext'd & drawn only	D
4	Brass (Free cutting)	61.5	..	..	..	Rem.	..	..	3.0	..	..	Best machining—same as for SAE 72 brass, 100%	All types sections in gauges down to ⅛-in. Ext'd and drawn only	B
5	Muntz Metal	60.0	..	..	..	Rem.	..	..	..	..	..	Moderate bends, good punching and brazing	Same as for yellow brass #3	C
6	Brass (Forging)	59.5	..	..	..	Rem.	..	..	2.0	..	..	Some bending with large radii. Good (80%) machining or hot forming	Same as for free-cutting brass #4	B
7	Bronze (Architectural	58.0	..	..	..	Rem.	..	..	3.0	..	..	Machines like free-cutting brass. No bending. Color match Muntz metal	Similar to free-cutting brass. Gauges to 0.062-in. can be ext'd and drawn	B
8	Bronze (Architectural)	57.0	..	..	..	Rem.	..	..	22.5	..	..	Good machining—80% No bending. Color match Muntz metal	Same as for Arch. Brz. #6. Plain Ext'd. only	B
9	Bronze (Manganese)	58.5	..	0.1	..	Rem.	..	..	..	..	1.50Fe 1.0Sn	Good wear, high strength. Poor machining—30%. Used in lieu of Naval brass for strength	Heavy, simple sections only. Min. gauge $\frac{3}{16}$-in. Plain ext'd only	C
10	Naval Brass	60.0	..	..	..	Rem.	..	..	..	..	0.75Sn	Little to moderate bending. Poor machining—30%	Same as for free-cutting brass. Plain-ext'd or ext'd and drawn	C
11	Naval Brass (Leaded)	60.0	..	..	..	Rem.	13.0	..	1.75	..	..	Good strength, good machining—70%	Same as for Naval brass # 10	C
12	Nickel Silver	43.5	..	..	..	Rem.	13.0	..	..	..	..	Some bending, hard and strong. White color	Similar to free-cutting brass. Gauges to $\frac{3}{32}$-in. Plain ext'd only	E
13	Aluminum Alloy 3S	..	..	1.2	..	..	..	..	..	Rem.	..	Good welding and corrosion resistance. Not heat treatable. Strength only fair—lowest of aluminum alloys	Minimum section 0.040-in. Good for complicated and hollow parts. Used in "as extruded" condition	Ext. speed up to 300 fpm A
14	Aluminum Alloy 14S	4.4	0.8	0.8	0.4	..	..	..	..	Rem.	..	High mechanical properties and hardness. Used where strength of 75S is not required. Heat treatable. Used for machine members	Minimum section ⅛-in.	A
15	Aluminum Alloy 17S	4.0	..	0.5	0.5	..	..	..	..	Rem.	..	Not ordinarily extruded. Used where machinability is a prime consideration, 200 to 1000%. Usually supplanted by 14S	Minimum section ⅛-in.	B
16	Aluminum Alloy 24S	4.5	..	0.6	1.5	..	..	..	..	Rem.	..	Strength not quite as good as 14S. Used for machine members	Better for thin or heavy sections than 14S. Min. section 0.040-in.	Extrusion speed 10 to 14 fpm A
17	Aluminum Alloy 61S	0.25	0.6	..	1.0	..	..	0.25	..	Rem.	..	Excellent forming qualities. High yield strength and corrosion resistance. Strength not quite as good as 24S	For complicated or hollow shapes Min. section thickness about 0.040-in.	B
18	Aluminum Alloy 63S	..	0.4	..	0.7	..	..	..	..	Rem.	..	Excellent working qualities. Strength fair. Lowest priced heat-treatable aluminum alloy. Good welding and corrosion resistance. Poor machinability	For complicated, and hollow shapes. Min. section thickness 0.040-in.	A
19	Aluminum Alloy 75S	1.6	..	..	2.5	5.6	..	0.3	..	Rem.	..	Highest strength aluminum alloy	Minimum section thickness 0.050-in.	Ext. speed 2 to 5 fpm C
20	Magnesium Alloys											High machinability, 350 to 1500%. Lowest weight. Good strength. Chrome-pickle finish normally used	All types complicated and hollow sections. Minimum section thickness 0.032-in.	Ext. speed 4 to 100 fpm A

* Minimum section thickness will vary with size of extrusion. Minimum section normally can be obtained with shapes which do not exceed 2 inches in longest dimension. In larger shapes minimum section is greater, reaching about ¼-inch with the largest shapes. Only materials so noted are adaptable for extruding hollow shapes. Machinability ratings based on free-cutting brass.

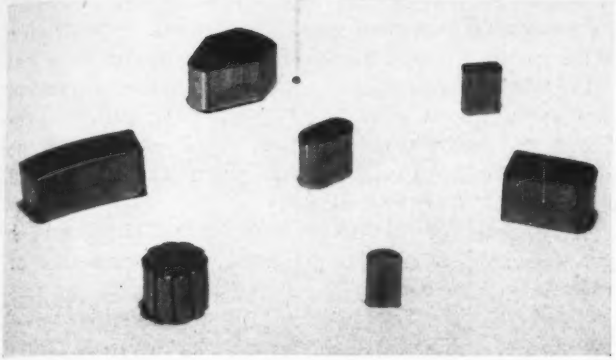


Fig. 5—Representative of group one, these shapes are simple, symmetrical and easiest to produce

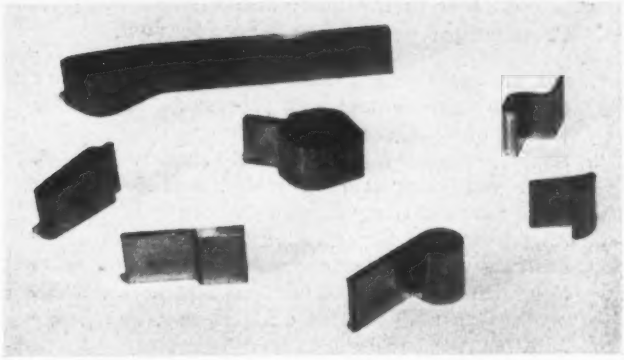


Fig. 7—Asymmetrical shapes, more difficult to extrude owing to extreme variation in size of section

trial by extrusion to determine the flow pattern to obtain equalized flow.

FLOW PATTERN EFFECT: Variety or intricacy of cross section depends upon the metal or alloy selected, and control of the flow of metal through the die. Reduction ratio between the billet cross-sectional area and the die area also influences flow. For practical operation this ratio should never be less than 10 to 1. In order to secure uniformly high properties, however, it is desirable to secure a ratio of 15 to 1 or preferably greater.

STRAIGHTENING: Each shape is handled as an individual problem. Dies are finished and designed to take advantage of present knowledge of particular metal flow characteristics to obviate excessive distortion. However a certain amount of twist, waviness or camber may occur, in which case straightening is employed. This is accomplished, if possible, by stretcher where the shape is symmetrical; or by hydraulic press if shapes are large and of heavy cross section as in the case of copper shapes for electrical use. Straightening by drawing with forming dies which produce no cold reduction may also be used.

Shapes of a symmetrical cross section often can only be straightened by bench and hand work. Large quantities of a single section, in any case, would warrant use of special rolls for straightening in a roll straightener.

DRAWING: Ordinarily, straightening is done directly after extrusion except where reducing draws are to be made. Cold reductions achieve increased hardness, increased tensile strength, or improved surface finish. All copper shapes and the higher copper content alloys must be cold-drawn to improve surfaces which are generally unsatisfactory due to high extrusion temperature. Drawing also develops closer dimensional control and meets demands for better tolerances where required. A standard draw bench is customarily used.

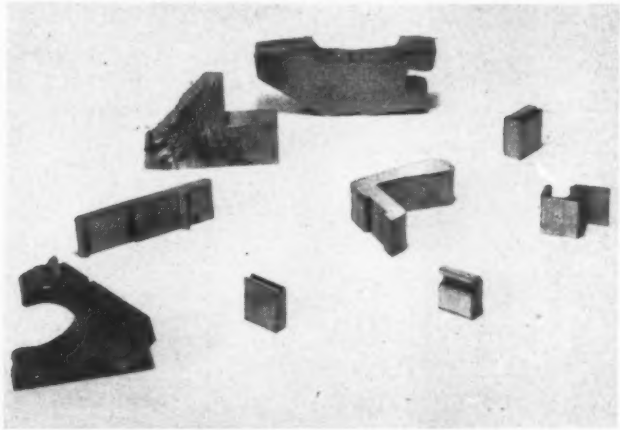
Generally, copper shapes for exacting electrical applications require two cold reductions. Brass alloys, including nickel silver, which have copper contents below 58 per cent are too brittle for cold reduction and are used "as extruded". Aluminum and zinc shapes seldom are drawn.

Some drawing operations are utilized which perform no cold reduction and are termed "forming draws". A shape much as a *U* would be extruded as a *V* to allow maximum die strength and life and then drawn to form the desired section.

DESIGN: Over and above the broad limitations outlined previously for the field of application, a number of particular design considerations affect the practicability of extrusions. To simplify the overall picture, extrusions in general can be broken down into a series of categories ranging from the simplest,

Fig. 6—Below—A representative group of simple, partially symmetrical parts with slots or serrations

Fig. 8—Below—Representative tongued and grooved shapes are limited somewhat by the particular material



most economical to the most difficult and complicated. These might be enumerated as follows:

1. Simple symmetrical shapes, *Fig.* 5. These are easy to extrude and are procurable in a wide variety of metals and alloys
2. Simple, partially symmetrical shapes, *Fig.* 6, often with slotted or serrated surfaces. These shapes are relatively easy to produce
3. Asymmetrical shapes, *Fig.* 7. These are more difficult to extrude because the metal tends to flow faster where heavier sections occur, small projections may not fill out properly, and gauge is difficult to maintain
4. Tongued or grooved shapes, *Fig.* 8. Where the tongue in the die has a length greater than three times its width at the narrowest point for aluminum, or greater than its width at the narrowest point for copper or copper alloys, the shape is classified as semienclosed and as a rule requires special handling consideration. As such it may become a special shape, item 6
5. Sharp corner shapes, *Fig.* 9. Die and pressure limitations demand that the intersection of two surfaces at angles less than 90 degrees be avoided if sharp corners are absolutely necessary
6. Special shapes. Includes shapes which do not fall into the previous categories, such as the "stepped" extrusions where size of cross section is increased at various stages of the extrusion process. Also shapes such as those with long, slender tongues in which the actual shape extruded is different than that desired and the final shape is obtained by rolling.

With simple and partially symmetrical shapes the only restriction which is necessary to observe is that in relation to minimum section thickness. General data regarding section gauge which can be extruded is shown in TABLE I along with other characteristics.

Details regarding minimum groove and serration size is shown in *Fig.* 10. *V*-serrations can be produced but of course the roots and crests will be rounded to 0.010-inch radius, the nearest practical approach to sharp edges.

A variety of plain or complicated tongued or grooved shapes can be produced. If a channel or groove is adjacent to an exterior surface and the separating leg is relatively thin in gauge, such a leg will be extruded in an extended or spread condition, *Fig.* 10, to allow maximum strength in the die tongue. This is particularly necessary in copper or copper-base alloy extrusion. The "as extruded" leg is then formed in a die to the desired shape. When such channels or grooves appear in multiple, the distance between channels should at least be equal to the channel width. Maximum groove or channel depth should be limited, if possible, to 1½ times the width for economic reasons. With aluminum extrusions the length or width of the groove or channel, i.e., the die tongue, should be limited to a maximum of three times the tongue neck. Occasionally this can run up to four times, but such shapes require special consideration and should be discussed with the manu-

TABLE II

Standard Commercial Tolerances for Shapes

Dimension (inches)	Tolerance (inches, plus or minus)					
	Brass	Muntz Metal Naval Brass	Mang. Brz. Nickel Silver	Leaded Brass Copper Naval Brass Mang. Brz. Muntz Metal	Aluminum Alloys Magnesium Alloys	
	Plain Ext'd	Plain Ext'd	Plain Ext'd	Ext'd & Drawn	Not Heat Treated	Heat Treated
0.000- 0.125	0.005	0.0075	0 010	0.003	0.007	0.010
0.126- 0.500	0.005	0.0075	0.015	0.003	0.010	0.015
0.501- 1.000	0.0075	0.010	0.020	0.005	0.015	0.020
1.001- 2.000	0.010	0.015	0.025	0.0075	0.017	0.025
2.001- 3.000	0.015	0.020	0.030	0.010	0.020	0.030
3.001- 4.000	0.020	0.030	0.035	0.015	0.025	0.035
4.001- 5.000	0.030	0.040	0.045	0.020	0.030	0.040
5.001- 6.000	0 035	0.050	0.060	0.030	0.035	0.045
6.001- 7.000	....	....	....	....	0.040	0.050
7.001- 8.000	....	....	....	....	0.045	0.055
8.001- 9.000	....	....	....	....	0.050	0.060
9.001-10.000	....	....	....	....	0.055	0.065
10.001-11.000	....	....	....	....	0.060	0.070
11.001-12.000	....	....	....	....	0.065	0.080

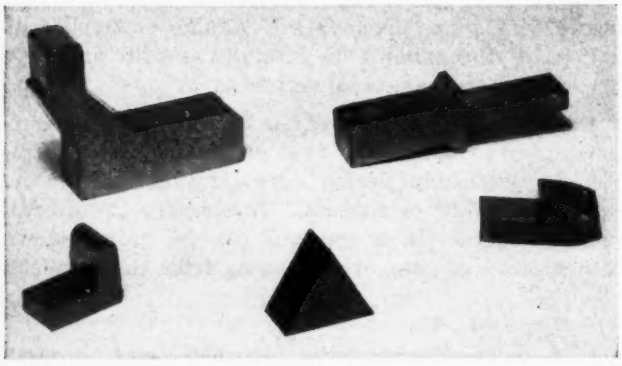
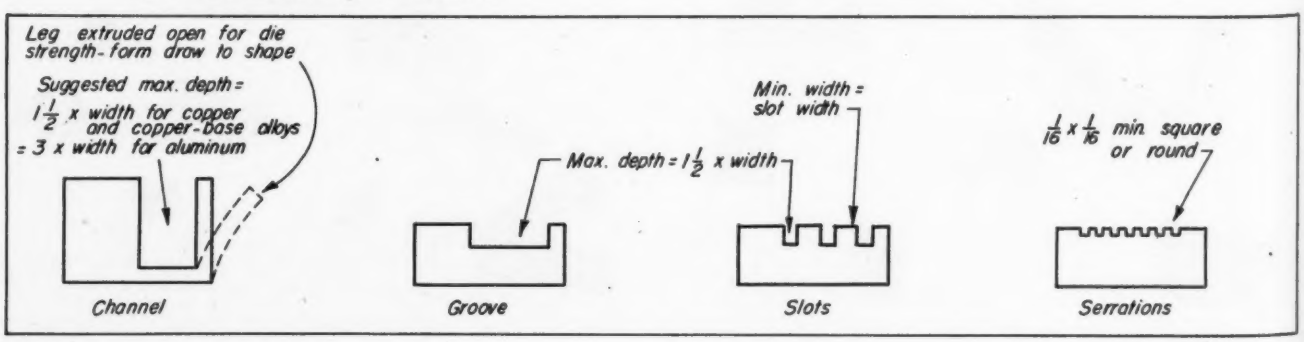


Fig. 9—Sharp-corner shapes normally require surfaces which intersect at angles greater than 90 degrees

Fig. 10—Below—Design factors relative to grooves and serrations which require attention


Leg extruded open for die strength- form draw to shape
Suggested max. depth =
1½ x width for copper and copper-base alloys
= 3 x width for aluminum
Channel
Max. depth = 1½ x width
Groove
Min. width = slot width
Slots
1/16 x 1/16 min. square or round
Serrations

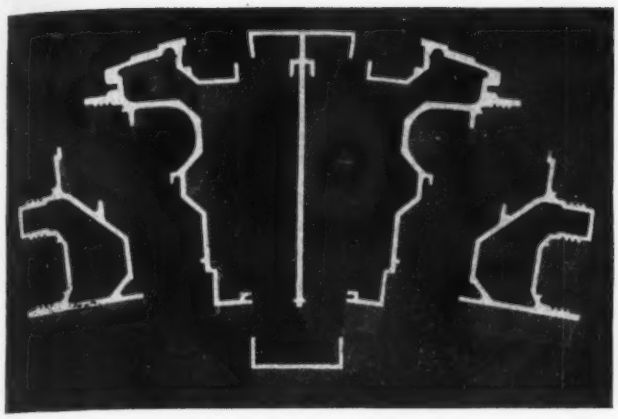


Fig. 11—Group of shapes showing some unusual hollow aluminum extrusions

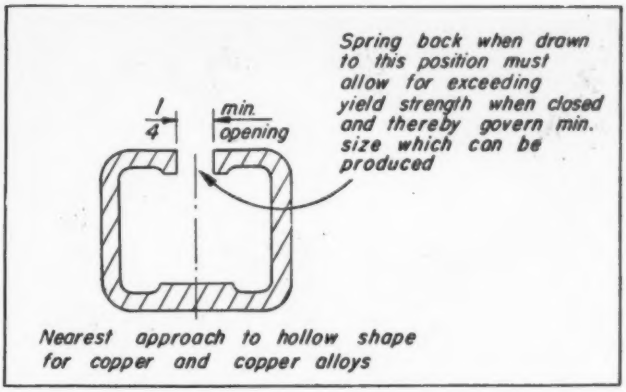
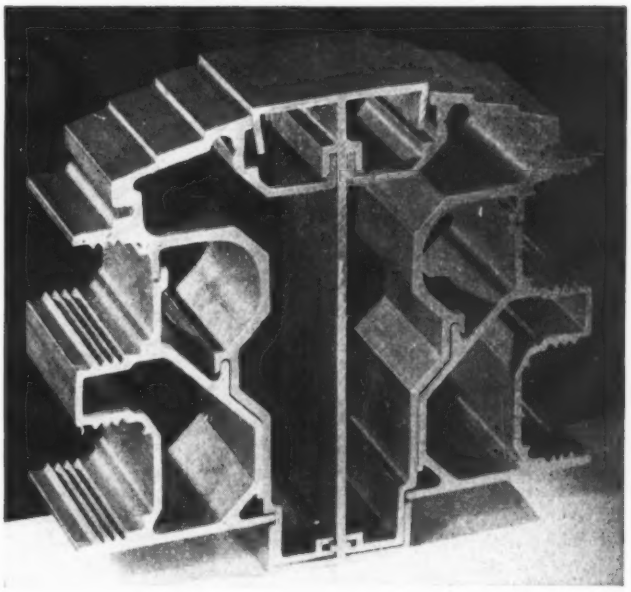

Spring back when drawn to this position must allow for exceeding yield strength when closed and thereby govern min. size which can be produced
1/4
min. opening
Nearest approach to hollow shape for copper and copper alloys

Fig. 12—Design indicating the nearest approach to a hollow section attainable in copper-base materials

Fig. 13—Below—Combination shapes of Fig. 11 shown assembled to form railway car post



facturer prior to completing the final design.

An almost unlimited variety of hollow shapes—simple, symmetrical, asymmetrical and special—can be readily produced, *Fig.* 11, in aluminum and magnesium alloys. As mentioned previously, though, copper and copper-base alloys normally cannot be handled in this way. The nearest approach to a hollow shape in these materials is produced by extruding in open position and die forming the section closed, *Fig.* 12. A minimum opening of ¼-inch is necessary owing to springback in forming.

All corners or edges considered as "sharp" are normally made with a 0.010-inch radius. Absolutely razor sharp corners are points of stress concentration and contribute to early die failures as well as subsequent processing difficulties. Truly sharp corners on parts should therefore be avoided wherever possible although occasionally corners can be brought to a sharp edge by the drawing operation without increasing the cost. In such cases the corners are extruded to 1/32-inch radii and cold reduced to be as sharp as practicable. Recommended economical minimum radius for plain extruded shapes is 1/32-inch and in the drawn condition 1/64-inch to avoid stress concentrations and excessive costs.

To obtain the structural strength of a box section, retain adequate simplicity, and use a minimum amount of metal to achieve a complicated section design, a combination of shapes can be used. Combination shapes can be produced so as to provide an assembly which interlocks to form a complete unit, *Fig.* 13. Tolerances can be controlled to insure a loose, sliding or drive fit for such members. Dovetails for interlocking assemblies, *Fig.* 14, have been standardized in a few sizes most commonly used with aluminum extrusions. Details for a ⅛-inch, 3/16-inch and 5/16-inch size are shown in *Fig.* 15.

Stepped extrusions mentioned previously, *Fig.* 16, have been developed for long parts such as aircraft wing spars where it is desirable to have an integral spar end cap. To date these extrusions are possible only in aluminum. Originally, it was necessary for one surface to be common to both large and small sections. Today, however, this limitation has been overcome and it is now entirely practical to produce stepped extrusions having no surface common to both large and small sections. These extrusions must be made large at one end only, other variations are not yet possible. Sections must be simple and should have no wide, thin flanges. An allowance of ⅛-inch for machining is usually adequate to take care of any lack of straightness or mismatch. In many cases 1/16-inch is sufficient but, because of the highly specialized nature of these extrusions, it is preferable to consult with the supplier prior to assuming a minimum adequate allowance.

MATERIALS: Most commercial shapes are extruded in copper, brass, aluminum, zinc, or magnesium. Copper of 99.9 per cent purity lends itself readily to shape production. A large number of copper-base alloys also can be extruded; those with the highest zinc content are the most plastic and can be produced in the most complex cross sections. Those in the range of 56 to 63 per cent copper are used the most, require the lowest pressure and are exceptionally plastic in the temperature range from 1200 to 1550 F. Hollow shapes cannot be made in copper or copper alloys.

As copper content increases, copper-base alloys be-

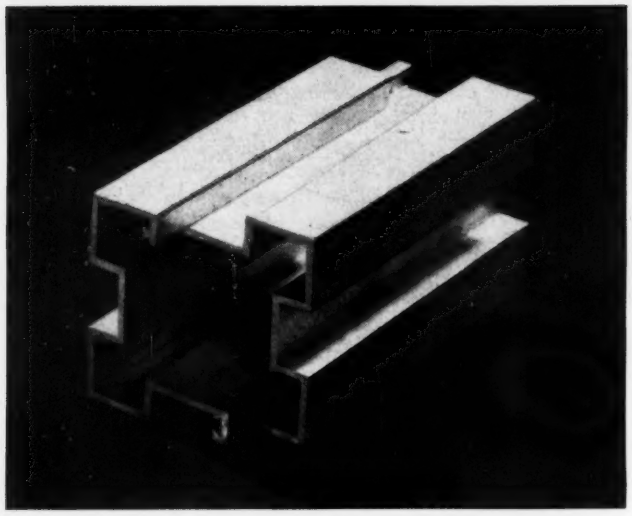


Fig. 14—Combination shape which uses a standard dovetail joint for interlocking

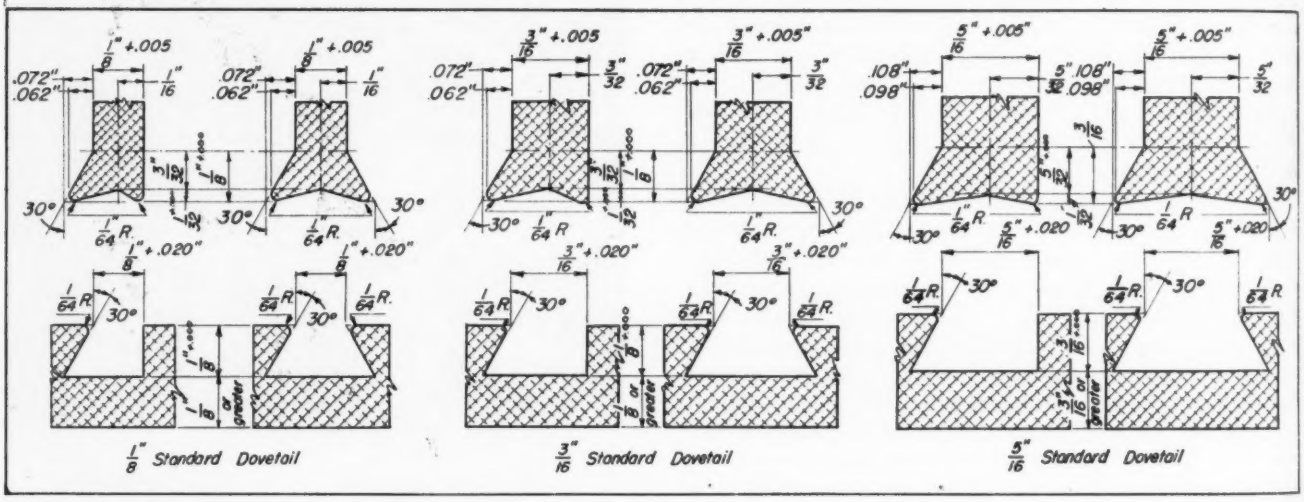
Fig. 15—Below—Dimensional details for the three standard dovetail joints used for aluminum extrusions

gons have been successfully produced. Cost of extruding zinc alloys is higher than for the brasses and consequently they are seldom used.

Aluminum and magnesium extruded shape production probably exceeds that of all the other materials. Most of the commercial light alloys can be extruded and owing to their favorable strength/weight ratio are finding increased use in portable equipment, vehicle bodies, textile machinery, and aircraft where weight savings are critical. Aluminum shapes are produced in 2S, 3S, 53S, 61S, 24S, 14S and 75S. Some of the salient characteristics, uses, limitations and comparative extrudability of various materials is shown in TABLE I.

Because of the variations in flow characteristics, reduction ratios between billet and die, and time of extrusion, a wide variation in structure is usually evident. The leading end of any extrusion differs sufficiently from the trailing end so that tensile property range in some materials may vary plus or minus

(*Concluded on Page* 184)

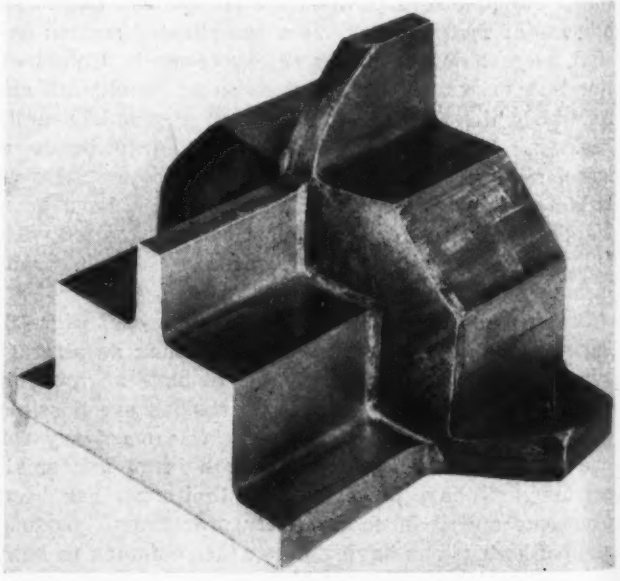


come increasingly stiff and difficult to extrude. Within the pressure limitations of present equipment the complexity of section will vary markedly with copper content. Commercial copper extrusions are generally limited to relatively simple and large solid shapes. Control of lead is important at the higher temperatures and generally alpha brasses or commercial coppers of high lead content are not commonly extruded. Large, simple sections have been made under controlled conditions with lead contents as high as 5 per cent.

In addition to these materials, extrusions have been made in phosphor bronzes, aluminum bronzes, nickel silvers—usually those in which the combined sum of nickel and copper falls in the range of 60 to 63 per cent. Nickel-silver alloys having higher combined percentages become extremely stiff at extrusion temperatures and can only be produced in the most simple and relatively large sections.

Cupro-nickel alloys, particularly those having 20 to 30 per cent nickel content, Monel, K-Monel, and Inconel have been extruded but to date only simple sections such as tubes, rounds, squares, and hexa-

Fig. 16—Below—Section of a simple stepped extrusion showing the portion at the step



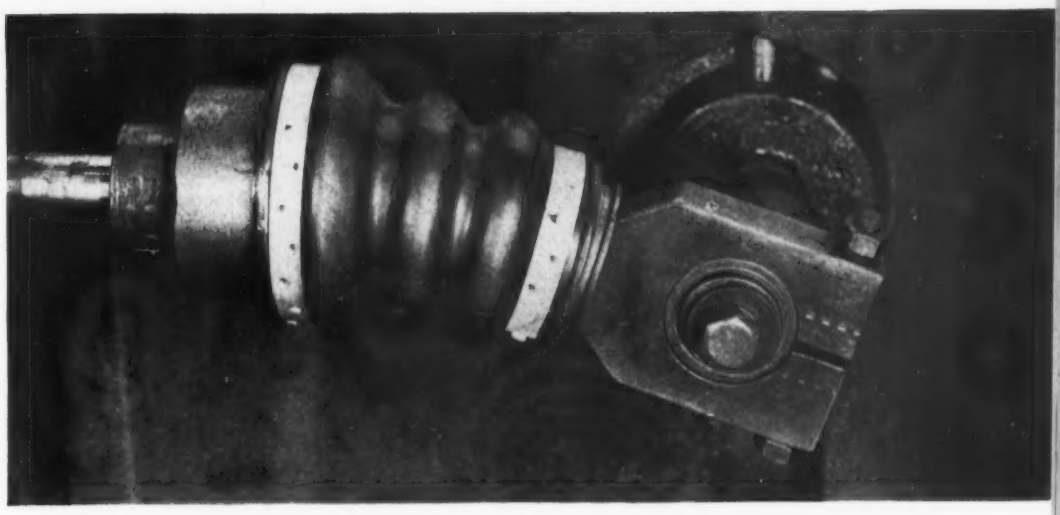


Fig. 1—Universal joint dust cover and grease retainer must withstand severe axial and lateral flexing

How to Design Molded and Extruded Rubber Parts

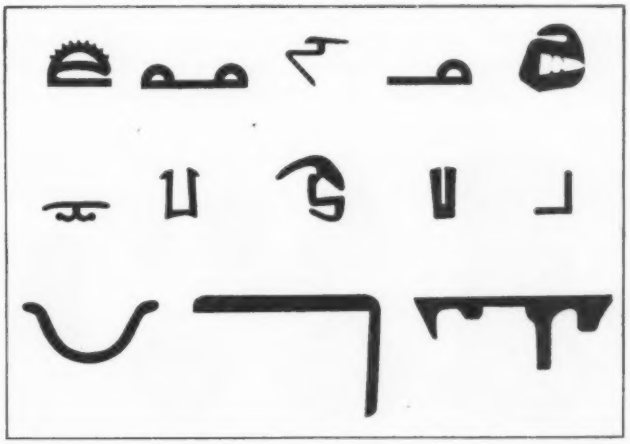
By John H. Gerstenmaier
Manager, Product Design and Processing
Goodyear Tire & Rubber Co.
St. Mary's Mfg. Div.
St. Mary's, Ohio

WHEN used as machine components, rubber parts such as shown in *Fig.* 1 must be designed with particular care. Not only must the material be well chosen to suit the application but processing methods must be given scrupulous consideration in order that dimension and tolerance specifications will be suitable and not result in expensive manufacturing operations. It is, then, the purpose of this article to briefly outline the usual methods used in making molded and extruded rubber parts, and show by example designs that are feasible and specifications that should be written.

MANUFACTURING METHODS: Molding methods can be classified into three basic types—compression molding, transfer-injection molding and full-injection molding. The preponderance of molding, however, is done in conventional compression type molds. Prepared stock is laid in the mold cavity as an individual piece, or strips are laid over several of the cavities. The two halves of the mold, coming together between the two platens of the press, then force the rubber into the contour of the cavity and thereby form the piece. Product examples of this type of molding are wringer rolls for washing machines and hose grips for vacuum cleaners.

Transfer-injection molding is coming into wide use since it permits an intricately shaped product to be successfully molded with greater efficiency. The rubber is first placed in a charging chamber and then, by means of a plunger, forced through small holes or

Fig. 2—Below—Typical shapes of parts that may be extruded from rubber. Contours shown represent parts made of natural, reclaim, GRS, Buna N, and Neoprene rubber, as well as combinations of these rubbers



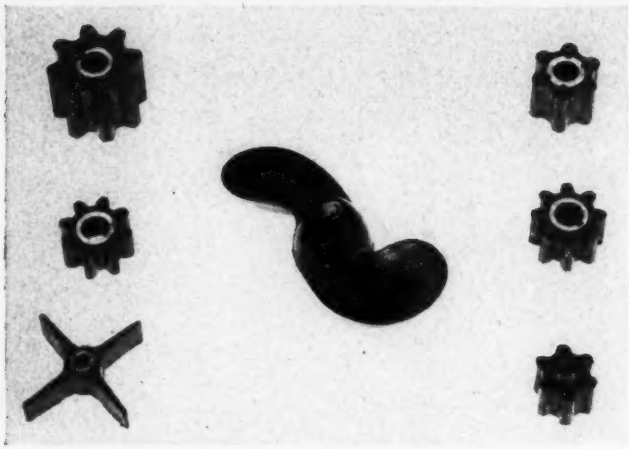


Fig. 3—Above—Pump impellers made of water-and-oil-resistant Buna N are bonded to metal cores by an adhesion that will last the life of the part

channels into the product cavity.

Extruding is done on a tube machine which consists of a screw rotating in a closed tube, the rubber being fed into the extruder and forced through a die by means of the rotating screw. Shape and size of the extruded stock is determined by the contour of the die. Next, the rubber is conveyed through a cooling tank into a cutting machine which is either synchronized with the tube machine to cut the parts to proper length, or used as a subsequent operation.

There is virtually no limit to the cross-sectional shapes that can be developed by the extrusion process, *Fig.* 2. However, the rubber must be compounded in such a manner that the section will not collapse during the cure. Therefore, it is generally not practical to design an extrusion with soft, 30 or 40-durometer rubbers.

RUBBER-TO-METAL ADHESIONS: A large portion of molded goods parts, *Fig.* 3, are adhered to a piece of metal. In such cases it is first necessary to especially prepare the metal so that good adhesion can be obtained. Certain types of compounded rubber will adhere to specific types of brassplate by vulcanizing. Therefore, it has been standard practice to use brassplating as a means of obtaining adhesion. However, there has been a tendency in the last four or five years toward use of cement type adhesives that produce excellent bonds without brassplating. Now, by phenolic or chlorinated-rubber cements, rubber-metal adhesions can be obtained with ultimate strengths which often exceed that of the cured compound. Also, the use of cements has opened up rubber-to-metal applications previously not feasible because the metals could not be brassplated. It is now possible to produce reliable adhesions to aluminum, die-cast metals, magnesium, carbon, etc.

Nevertheless the brassplate process still is the work horse of metal-to-rubber preparation. It is very reliable and less inclined to as large a variation in adhesion results as with cement type adhesions. Brassplating also provides a slight coat of rustpoofing, which is often desirable. In the case of axle bumpers for automobiles, for example, it is not necessary to paint the metal prior to shipments to the automotive company.

APPLICATIONS: Because of its inherent high resiliency and flexure life, rubber is particularly suitable for use in parts experiencing flexure or vibration. Examples include boots, gaskets, vibration mounts, vibration dampeners, and seals. In addition, because of the intricate shapes into which rubber can be molded, parts requiring decorative effects can be made easily and economically.

TABLE I—Dimensional Tolerances

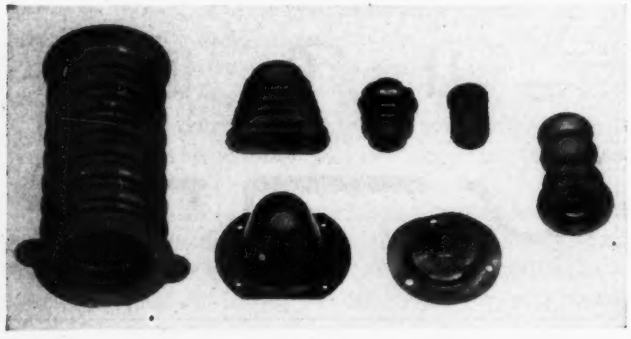
Net Rubber Thickness (Inches)	Overall Thickness Tolerance (Inch)
0 to ½	±0.010
½ to 1	±1/64
1 to 2	±1/32
2 to 3	±3/64

In order to show typical uses of molded and extruded rubber as it pertains to machine design, it is convenient to give examples of several types of parts. The first of these is diaphragms used to convert vacuum or air pressure into mechanical energy. Most diaphragms are now being made of natural rubber compound because of its excellent flex characteristics. It should always be remembered that in applications where a diaphragm is required, the design should be so worked out that all the movement is made by flexing the rubber rather than by any tendency toward stretching the rubber.

Fluted boots and bellows, *Fig.* 4, are made of rubber because of the flexibility of the material and ease of manufacture. Examples of this application are vacuum cleaner parts, and automotive and industrial equipment components. An interesting example in this category is the universal-joint dust cover and grease retainer, *Fig.* 1, which must retain the lubricant around the universal joint and still withstand severe rotational and lateral flexing when a car is traveling at high speed over a relatively rough road. In most cases, the boot is used to keep dust and dirt out of a mechanism. There is usually no specification made on this type of part other than that the life be reasonably long and that the price be low. Natural rubber or GRS, whichever is cheaper, is used.

Vibration mounts, *Fig.* 5, are commonly made of rubber because of its resilience and inherent damping characteristics. All automotive and aircraft engines

Fig. 4—Below—Dust covers made from natural rubber and GRS compounds must be soft, flexible and abrasion resistant and have low permanent set



are now mounted on rubber, and an automotive vibration dampener used on some automobiles to take the place of a large flywheel uses rubber as a basic element. In all applications of rubber for vibration damping or engine mounting, the compound selected must have a minimum amount of compression set so there will be little tendency for the rate to change or the position of the machine to change after it has been placed in use.

One rubber part widely used in the automotive industry is the shock absorbing bumper which is designed to take up the shockload that cannot be carried by the regular springing system without bottoming. Hardness of these bumpers is so designed that they will pick up the load from the spring without showing any abrupt change in the load deflection curve. In this case the compounded rubber must have a great resistance to impact and good adhesion to the metal mount is necessary.

DESIGN FUNDAMENTALS: In designing rubber parts certain rules, *Fig.* 6, should be followed in order to achieve good performance at low cost. These are as follows:

Dimensional Tolerances: Tolerance on dimensions not affected by flash thickness should not be less than plus or minus ½ per cent. Tolerance on dimensions perpendicular to the flash line should not be less than the values indicated in TABLE I.

Eccentricity: Runout or eccentricity specifications should not be less than the values given in TABLE II. If metal sleeves are used in the part, the total allowable eccentricity will be the sum of the eccentricities resulting from the tolerances of the metal diameters plus those shown in the table.

TABLE II—Minimum Eccentricity

Part Diameter (Inches)	Eccentricity (Inch)
0 to 2½	0.020
2½ to 5	1/32
5 to 10	1/16

Flash Extension: When close flash removal is not necessary, it should be so indicated on the part drawing. This may be done by a note such as, "1/16-inch flash extension allowable," or where close flash removal is necessary for appearance or proper functioning, then a note such as, "Remove all flash," or "1/64-inch flash maximum allowed" should be placed on the drawing. It is standard practice to place the mold parting line at a location which will result in the most simple mold design and facilitate production operations. If, for reason of appearance or performance, a flash line should not be located at a particular section, it should be so noted on the part drawing. The part drawing should indicate where the rubber should be removed from the metal on rubber-metal parts.

Finish: If special finish is required for appearance or performance, it should be so noted on the drawing. Standard procedure is to provide a mold with a machined finish. It is possible to provide molds with polished or chrome plated finish, but this is not regarded as standard practice and involves increased manufacturing cost.

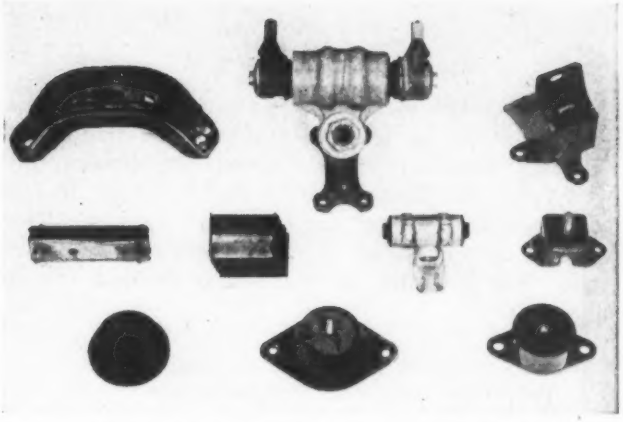


Fig. 5—Above—Engine mounts use natural rubber. Optimum combination of resilience, high tensile strength and low permanent set is required for this service

Adhesion: For best adhesion results, metals should be smooth. Corrugations, serrations, knurling, etc., decrease the effective adhesion.

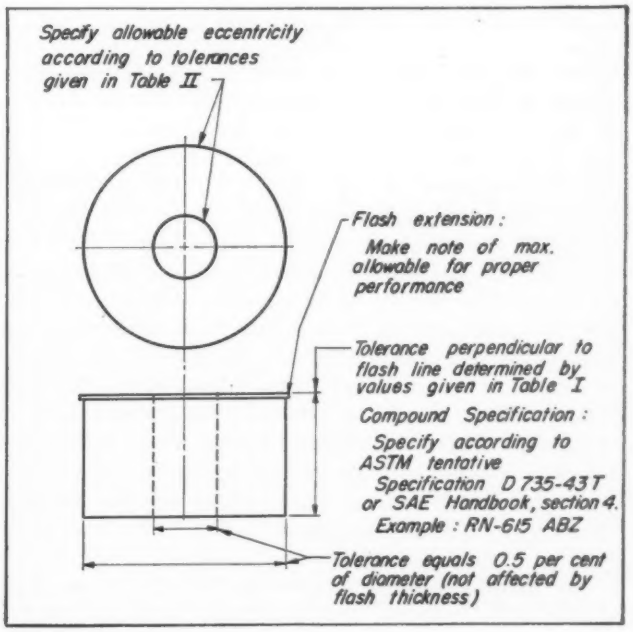
Fillets: Large fillets should be used at sections where rubber joins steel on flexed rubber-to-metal parts.

Undercuts: When 80 to 95-durometer rubber is specified, undercuts should be avoided. A slight draft should be provided when 90 to 95-durometer hard rubber is used.

Compression Rates: When shear or compression rates are specified, a tolerance of plus or minus 15 per cent is required. This allows for variation in the modulus of rubber, discrepancy in metal dimensions and discrepancy in methods of testing.

Material Specification: Compounding requirements should, wherever possible, be specified according to the ASTM tentative specifications D735-43T or section 4 of the SAE hand book.

Fig. 6—Drawing of typical rubber part showing method of specifying dimensions, finish and material


Specify allowable eccentricity according to tolerances given in Table II
Flash extension: Make note of max. allowable for proper performance
Tolerance perpendicular to flash line determined by values given in Table I
Compound Specification: Specify according to ASTM tentative Specification D 735-43 T or SAE Handbook, section 4. Example: RN-615 ABZ
Tolerance equals 0.5 per cent of diameter (not affected by flash thickness)

Channel-Grid St

A method for stiffening arge

By Charles Bailey
Chief Engineer

*General Engineering Division, John I*s Co.

IN the design of seven large gear cases, the problem arose as to how stiffening of the frames might best be achieved. Essentially, these frames were large flat-plate members, *Fig.* 1, subject to high compressive stressing and dynamic loading. They were to be arc welded of rolled plate and steel castings. The stiffening method finally devised was designed to:

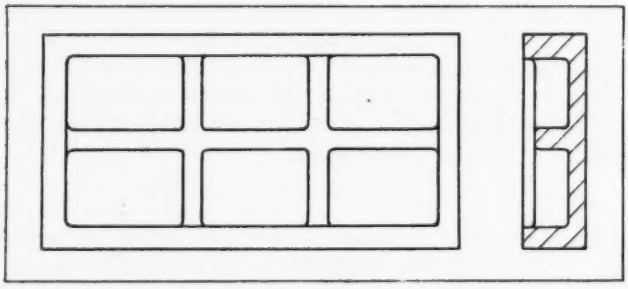
1. Simplify an existing complex design
2. Reduce fabrication and assembly time
3. Make maximum use of limited facilities and manpower
4. Produce a stiffer structure permitting faster machining while retaining required close tolerances of shaft alignment and oil tightness
5. Improve the appearance of the finished machine
6. Reduce cost.

Representative of sound design for cast fabrication is the rib and flange-stiffened panel of *Fig.* 2. It is traditional and designers have tended to use it for welded structures also. In doing so, they have mimicked the cast design of *Fig.* 3*a*, the result being shown in *Fig.* 3*b*. This design, however, is wasteful of material and labor because the degree of stiffening is less than that possible by using the tee section of the same weight shown in *Fig.* 3*c*. Figure 3*d* shows a channel-section stiffener which has advantages over any of the other methods.

A typical panel of channel-grid construction is shown in *Fig.* 4. The deep channel stiffeners are arranged vertically, their flanges in contact with the plate web and welded thereto by means of continuous fillet welds. Ends of the channels are likewise welded to the boundary flanges. Panels thus produced are further subdivided transversely by similar bent-plate channel stiffeners which are welded to the web plate and around their edges to the vertical channels at all intersections.

Fig. 1—Right—Gear case used in ship propulsion unit is built up of channel sections and plates continuous welded

Fig. 2—Below—Traditional method of designing reinforced panel structure for production by casting



This article is based on an award-winning paper in the recent "Design-For-Progress Program" sponsored by the James F. Lincoln Arc Welding Foundation.

d Stiffener System

ng large flat machine panels

and David Boyd
Works Manager

n Iron Co. Ltd., Toronto, Ontario, Canada

It will be seen from *Fig.* 4 that a panel fabricated from a web plate and bent channels is in effect a series of columns of rectangular section tied together at one face by the web plate and, at the other face, tied together and restrained by the transverse channel webs. Adequate diaphragming is provided by the transverse channel flanges. This permits proportioning the box columns by simple analysis to carry the vertical loads imposed on the structure, thus eliminating the former wasteful empirical methods.

Direct transmission loads from the shafts contained within the gearbox were in the order of five tons on each high-speed pinion shaft, seventeen tons on each intermediate shaft, and forty tons on the main propeller shaft in combination with an axial thrust of sixty tons. The channel-grid stiffener system was proportioned for these forces using the very low unit stress of 3000 psi after reasonable allowance for local bending.

It is considered that the vibrations induced in the gear case by the propulsion drive will be effectively

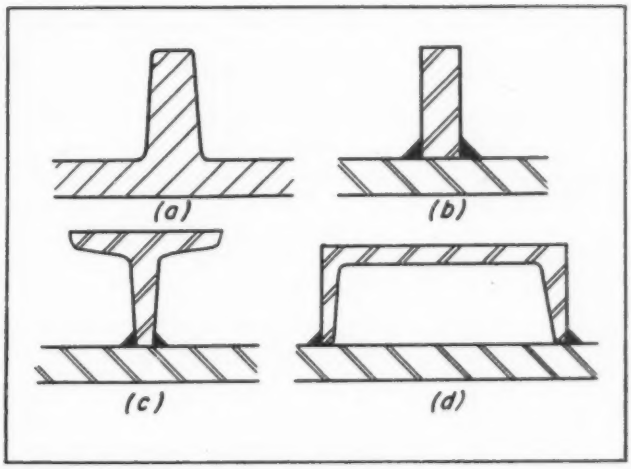


Fig. 3—Methods of reinforcing plate structural members. (a) Conventional cast rib; (b) welded rib is adaptation of cast design; (c) welded-on tee section offers greater strength than straight rib at same weight; and (d) welded-on channel effects greater rigidity than other three

damped by the short spans and deep sections employed and by the effective shear bracing afforded in all normal planes by the channel grid. In short, the channel grid approximates a double-web panel adequately framed internally without the disadvantages of welding through access holes or resort to plug and slot welds normally employed to attach outer plate web to internal plate stiffeners.

In certain applications of the channel-grid stiffener system it may be advisable for aesthetic reasons to present to the eye a smooth outer surface with dominant vertical lines. This effect may be achieved readily by reducing the flange depth of the transverse channels by about ten per cent and equipping the grid with plates between the vertical stiffeners, the panel surfaces being placed somewhat be-

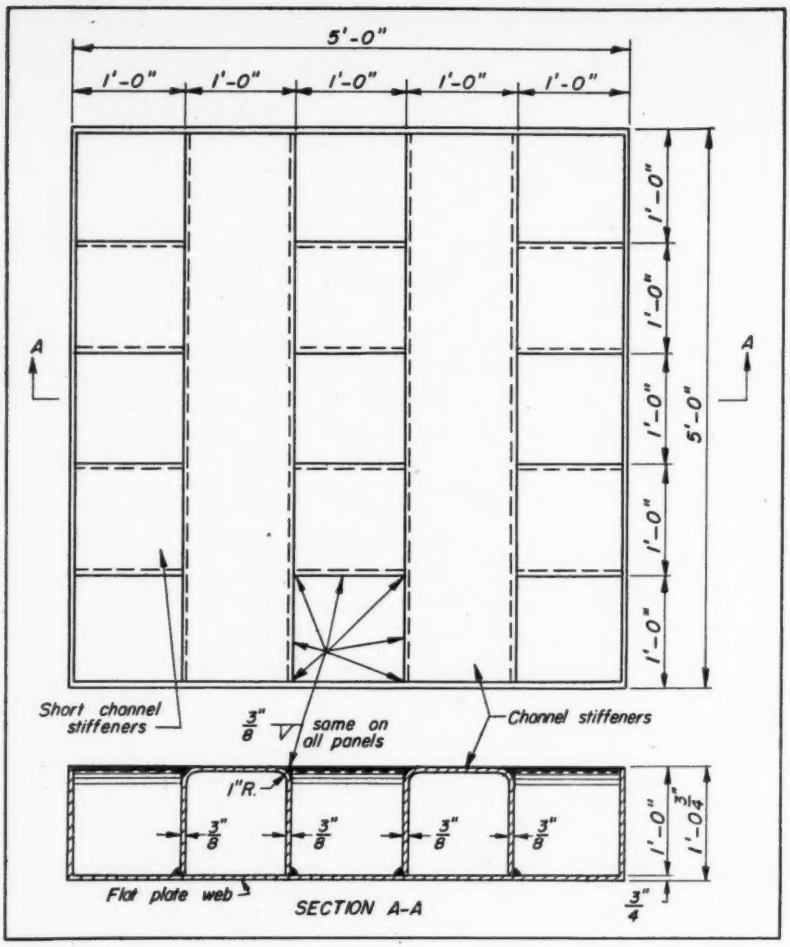


Fig. 4—Left—Typical channel-grid stiffened structure offers maximum rigidity

low the level of the stiffener webs.

Welding sequences were normal throughout. Panels were completely fabricated and assembled to form the basic structure. Bearing blocks, of cast steel, were then installed and welded completely. No preheating was used, but the complete structure was stress relieved.

Advantages offered, from an engineering standpoint, by channel-grid stiffener design as compared to the traditional rib-and-plate design, are matched by advantages in economy of fabrication and materials employed. A comparative cost estimate of the 5 by 5-foot panels shown in *Figs.* 4 and 5 follows:

Channel Grid-Stiffener Design

Material: 720 lb @ $.028	$20.00
Weld Electrode: 80 ft—⅜ fillet	5.00
Welding Labor @ $1.00/hr	8.00
Fabricating and Assembly @ $1.00/hr	5.00
	$38.00

Rib and Plate Design

Material: 1200 lb @$.028	$34.00
Weld Electrode: 80 ft—⅜ fillet	11.00
Welding Labor @ $1.00/hr	17.00
Fabricating and Assembly @ $1.00/hr	8.00
	$70.00

Note: Estimates do not include items common to both designs such as web plates, flanges and welding of flanges to web plates. Overhead and other similar expenses also are excluded.

Thus it is seen that for the case chosen, the channel-grid stiffener design shows a saving of 45 per cent. In addition, rigidity of the finished sections permitted much higher machining speeds and feeds. Because of the superior machining results achieved, the amount of scraping required to make oil-tight metal-to-metal joints was reduced from a matter of weeks to hours.

During the development, it was anticipated that, since distortion and residual stress are functions of relative concentration of weld metal, the better distributions obtained through the channel-grid stiffener design would minimize these problems. This was amply borne out in fabrication, the finished sections being true and accurate to dimension. Machining allowances were 3/16-inch on all faces and proved to be more than needed to clean up all surfaces.

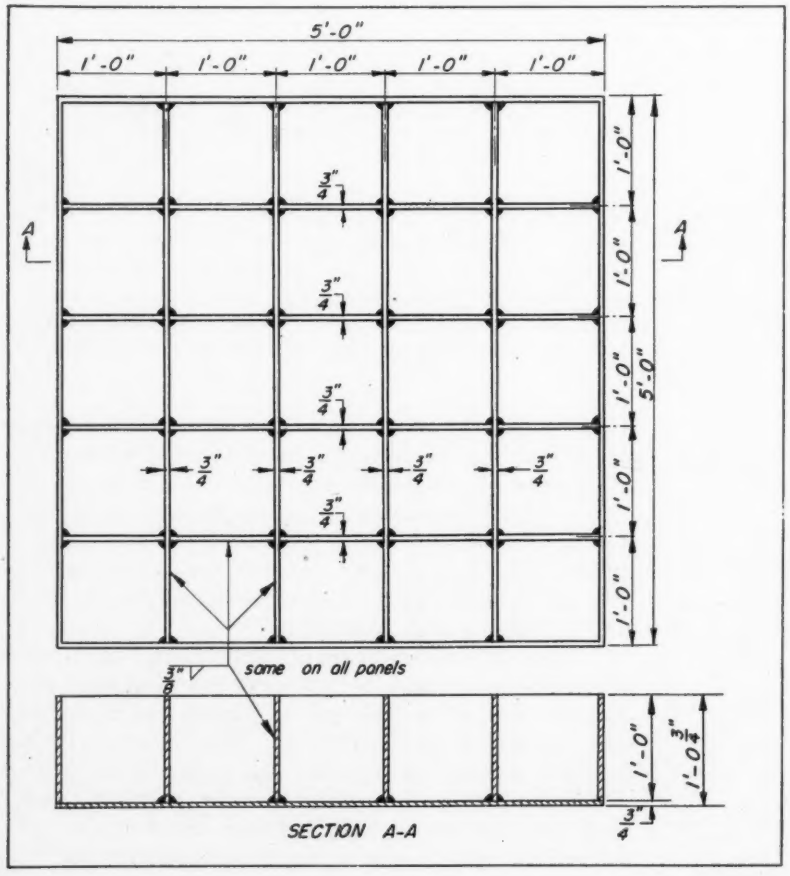


Fig. 5—Left—Typical rib-stiffened structure which does not have the rigidity nor the appearance offered by a channel-grid stiffened structure

Applying Time and Motion Study Principles in Design

By M. E. Mundel
Associate Professor of Industrial Engineering
Purdue University
Lafayette, Ind.

and R. C. Howell
Chief Industrial Engineer
American Steel Foundries
Alliance, Ohio

MOTION and time study demands, for realization of its full potentialities, that industry consider it a true staff function. It must be though of as an important activity in which everybody in a plant participates. The heads of various functional departments of a plant must realize that their departments cannot operate as independent, self-sufficient units. Their efforts must be integrated to achieve maximum production at lowest cost. To make this integration possible it is necessary that all individuals concerned in the production picture understand the full meaning of the application of motion and time study.

Motion and time study is a scientific systematic procedure for analyzing the raw materials, product designs, processes, tools, workplace, equipment, and hand and body motions involved in production in order to determine the easiest and most economical way to produce.

Properly applied, motion and time study can serve as an effective aid in co-ordinating diverse plant activities. Years of varied industrial experience can be unlocked, co-ordinated and put to work more effectively in an integrated production program—but only if motion and time study is treated as a true staff function *with adequate executive backing.*

Machine designers of production equipment have frequently operated in what is tantamount to a vacuum concerning the requirements of the individuals who must operate their equipment. This may appear

unduly harsh but in many cases where an attempt has been made to get out of this vacuum reliance has been placed on haphazard, inadequate rules of thumb. What is needed is a systematic approach to the problem. On the other side, motion and time study analysts have often fallen into the erroneous practice of developing improved procedures and equipment after the original procedures and equipment have been installed. This is not only wasteful but entirely unnecessary. Such situations have been brought about for the most part by a lack of understanding of the true area in which motion and time study operates.

There are five major factors which affect the economy of production methods on any job:

1. Hand and body motions
2. Tools, workplace and equipment and their effect on item 1
3. Process and its effect on items 1 and 2
4. Product or part design and its effect on items 1, 2 and 3
5. Raw material and its effect on items 1, 2, 3, and 4.

It will be noted that the design of tools, workplace, and equipment does not exist as a separate function apart from the hand and body motions of the people who must use this equipment. Also, such things as the design of process, part or product design and the selection of raw material must be translated into action through tools, workplaces and equipment. The designer of factory production equipment, therefore, is one of the key men in the production picture. It is only through his active participation in the selection of the raw material, the detailed product and process design, and in the design of work methods that he may properly discharge his obligation concerning the design of effective tools, workplaces and equipment.

The results from such a broad approach to a job may be illustrated by reference to a case study of the production procedures and equipment for the E-60 draw-bar core at The American Steel Foundries' Plant at Alliance, Ohio. The core box, and a top view and front view of the original core making equipment are shown in *Fig.* 1.

Modern motion and time study consists of the application of a series of logical steps representing the scientific approach to the production problem. It

Fig. 1—Below—Core box, top and front views of the original core making equipment

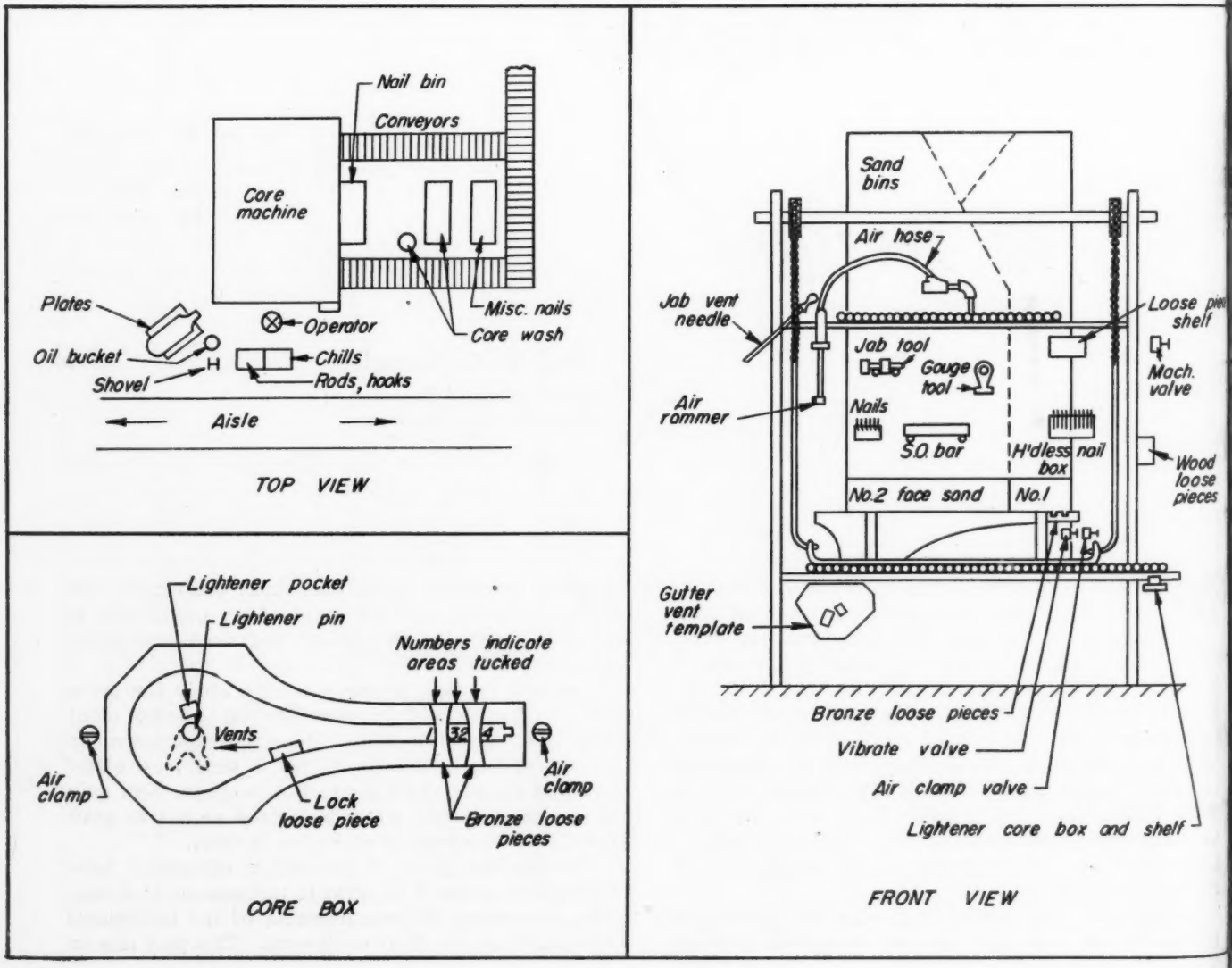


Fig. 2 — Right — Blank form of a possibility guide used in determination of the area for modification

POSSIBILITY GUIDE

Name of Operation _____ File Number _____
Operation Number _____ Analysis by _____
Date _____

Class of Change	Hand and Body Motions	Tools, Workplace and Equipment	Process	Product Design	Raw Material
1					
2					
3					
4					
5					

Fig. 3—Below—Possibility guide with partial list of suggestions for E-60 core making

POSSIBILITY GUIDE

Name of Operation CORE PRODUCTION ON GOULD-ROLLOVER DRAW. MACHINE File Number ASF-A-GR-1
Operation Number 26 Analysis by R. HOWELL
Date 9/47

Class of Change	Hand and Body Motions	Tools, Workplace and Equipment	Process	Product Design	Raw Material
1	TUCK LIGHTENER PIN WITH LH WHILE RH TUCKS LOCK PIECE PRODUCE ENTIRE CORE IN ITS NORMAL SUCCESSIVE STEPS TO ELIMINATE WALKING				
2	ELIMINATE WASTE STRIKE-OFF MOTIONS PERMITS USE OF BOTH HANDS IN OPERATION OF DRAW (RH) & CLAMP (LH) ELIMINATE OPEN & CLOSE APRON MOTIONS	REVISE OPEN POSITION OF CORE PLATE RELOCATE DRAW LEVER ELIMINATE HINGED SAND DELIVERY APRON AND REVISE CORE BOX			
3	ELIMINATE DIPPING REDUCE NO. OF PASSES ELIMINATE HAND FILLING OF CORE BOX ELIMINATE GETTING & PLACING LOOSE PIECES	SUBSTITUTE SPRAY FOR SWAB INSTALL SAND HOPPERS AND CHOP GATES REVISE CORE BOX	SPRAY ON CORE WASH DELIVER SAND MECHANICALLY INTO CORE BOX ELIMINATE SPLIT BUSHING LOOSE PIECES		
4	ELIMINATE TUCKING POST ELIMINATE MAKING SEPARATE GREEN SAND LIGHTENING CORE & NAILING LIGHTENING CORE TO MAIN CORE GREATLY REDUCED	MOVE LIGHTENER POST TO END OF CORE BOX ELIMINATE LIGHTENER CORE BOX & SHELF ONLY BLOWER & MOLD REQUIRED	ELIMINATE TUCKING POST SEPARATE LIGHTENER CORE NO LONGER REQUIRED CORE BOX PACKED IN SINGLE OPERATION	RELOCATE LIGHTENER POST REVISE CORE BOX TO INCLUDE LIGHTENER CORE PRODUCE ENTIRE CORE OR DRAG CORE ON CORE BLOWER	
5	ELIMINATE POSITIONING OF FACING SAND ELIMINATE BENDING & PLACING OF 2 RODS FACILITATE HANDLING OF CORE PLATE	ELIMINATE FACING SAND SPACE PROVIDE LONG ROD SPACE AT WORK PLACE REDUCE PRESENT WT. OF CORE PLATE (65LB.)	ELIMINATE MAKING & POSITIONING FACING SAND ELIMINATE BENDING OF RODS X	CORE OF HOMOGENEOUS SAND 2 STRAIGHT RODS REPLACE 2-16" STRAIGHT RODS AND 2-24" RODS. STIFFER CORE RESULTS X	USE ONE PURPOSE SAND USE 2 LONG STRAIGHT RODS IN PLACE OF 2-16" STRAIGHT RODS AND 2-24" RODS NOW BEING BENT BY CORE MAKER USE LIGHT ALLOY CORE PLATES

Fig. 4—Left—Section of process chart product analysis form for the E-60 cores

is worth noting that these steps aid in substituting *systems* for *ingenuity*. The steps are as follows:

1. Determination of the area for modification
2. Analysis of the job in terms of steps possessing known characteristics
3. Application of basic data and check lists to these analyses or descriptions
4. Formulation of a hypothesis involving a proposed method of doing the job
5. Testing, on paper, of the desirability of the suggested method
6. Standardization of the suggested method
7. Application to the shop.

One of the most useful techniques for performing step 1 (the determination of the objective) by enumerating the possibilities of deviations from a proposed or existing method is the construction of a *"Possibility Guide."* On a possibility guide, such as that shown in *Fig.* 2, are listed the various alternative procedures which stem from changes in each of the five classes. Necessary changes in the lower classes to make the greatest use of the proposed changes in the higher classes are also given. A possibility guide with some suggestions for the case study job of making the E-60 core is shown in *Fig.* 3. Naturally, to make such a possibility guide properly, a certain familiarity with the job in question is required. The personnel in a plant usually have a sufficient familiarity with the job to list such proposals as are given in *Fig.* 3. If not, they may acquire the necessary familiarity through the construction, by a member of the plant staff, of an analysis such as ture of E-60 draw-bar cores, part of which is given in *Fig.* 4. "The process chart product analysis is a graphic means of portraying the separable steps of the procedure involved in performing the necessary work required to modify a product from one stage of completion to another".*

The possibility guide shown in *Fig.* 3 is only a partial list of the suggestions which resulted when the works manager, core department foreman, industrial engineer, staff industrial engineer, and plant engineer sat down to discuss the possibilities on this particular job.

* M. E. Mundel, *Systematic Motion and Time Study*, Prentice-Hall, New York, 1947, page 28.

Fig. 5—Right—Section of original right and left-hand operation chart for the E-60 cores

ORIGINAL **OPERATION CHART**

E-60 DRAW BAR CORE BOXES 1, 2, 12, 13, 15 by T. McFall 9/47

Left hand description	Symbol	Symbol	Right hand description
To APRON CATCH			To APRON
TAKE HOLD			TAKE HOLD
RELEASE CATCH			LOWER
To #1 FACING BIN			To #1 FACING BIN
SCOOP SAND TO SHANK			SCOOP SAND TO SHANK
PULL To BOX			PULL To BOX
SCATTER SAND IN BOX			SCATTER SAND IN BOX
To SHANK END OF BOX			To SHANK END OF BOX
TUCK #3 LOCATION WITH FINGERS			TUCK #1 LOCATION WITH FINGERS
To #4			To #2
TUCK #4			TUCK #2
To #1 FACE BIN			To #1 FACE BIN
SCOOP SAND WITH HAND			SCOOP SAND WITH HAND
To HEAD OF BOX			To HEAD OF BOX
TUCK LIGHTENER POCKET			TUCK LIGHTENER POCKET
To NAIL BOX			To NAIL BOX
PICK UP ONE NAIL			PICK UP ONE NAIL
To LIGHTENER POCKET			To LIGHTENER POCKET
PLACE NAIL AND LET GO			PLACE NAIL & LET GO
To #2 BIN			To #2 BIN
SCOOP BY HAND			SCOOP BY HAND
To CORE BOX			To CORE BOX
SCATTER SAND IN HEAD			SCATTER SAND IN HEAD
To LIGHTENER PIN			To LIGHTENER PIN
TUCK SAND WITH FINGERS			TUCK SAND WITH FINGERS
To LOCK LOOSE PIECE			To LOCK LOOSE PIECE
TUCK SAND WITH FINGERS			TUCK SAND WITH FINGERS

The chart shown in *Fig.* 5 is a section of the right and left-hand operation chart of the original method of making E-60 drawbar cores, using existing equipment. This analysis was made by the plant industrial engineer and was used to make a right and left-hand operation time chart which not only gave the sequence of and simultaneity of hand operations in the orginal method, but also the time for each step. This chart, a section of which is shown in *Fig.* 6, was made by the addition of stop-watch data to the original right and left-hand operation chart. These analyses were indicated as necessary by the possibility guide.

To these analyses, the aforementioned group proceeded to apply the standard check lists and basic information of the motion and time study group. The aim was to eliminate any unnecessary steps, combine steps, possibly rearrange them in the easiest sequence and to simplify the steps whenever possible. These analyses were also used to evaluate the desirability of the suggestions on the possibility guide.

From the suggestions developed by this group, a time chart of a proposed method was constructed which, when evaluated on paper, indicated that it would be possible to increase production by 39 per cent by using the proposed method. The proposed method involved modifications of material, design, process, equipment and work motions. An experimental installation of the suggested method was made and a 40 per cent increase in production was realized.

A list of the suggestions generated on the possibility guide and in subsequent analyses, which were tested on paper prior to application, are shown in TABLE I along with the net results. These procedures were successful in this particular instance because there was co-operation in the plant. There was co-operation because the top executive group understood, participated in and stimulated the program. All of the people concerned with the changes had a knowledge (obtained through a series of special conferences) of the procedures used to develop the changes and also had a complete understanding of the graphic methods used to present and test these changes. Any plant can achieve similar results if they meet these requirements.

It would have been more economical if all those concerned with the design, operation, and utilization

TABLE I
Possibility Guide Suggestions and Test Results

Change	Other classes affected	Successful	Not Successful	Still experimental
CLASS 5—Raw Materials				
1—Use one purpose sand to eliminate making and positioning facing sand	1,2,3			V
2—Use U-shaped prebent wire in place of two nails to reinforce the lightener pocket (didn't reinforce properly)	1,2,3,4		V	
3—Use two long straight rods in place of two 16-inch straight rods and two 24-inch rods now being bent by the core maker	1,2,3,4		V	
4—Use light alloy core plates (present weight 65 lbs)	1,2			V
5—Use aluminum dryers in place of positioning two wood loose pieces, parting and bedding sand	1,2,3		V	
6—Eliminate the use of core wash	1,2,3,4		V	
CLASS 4—Product Design				
1—Relocate lightener post to end of box to eliminate tucking post	1,2,3		V	
2—Eliminate making a separate green sand lightener core and nailing lightener core to main core by revision to core box	1,2,3		V	
3—Eliminate dowel jab vent	1,2,3			V
4—Eliminate venting with ⅛" diam. tool (vent found necessary)	1,2,3		V	
5—Eliminate gutter venting (vent found necessary)	1,2,3		V	
6—Reduce gutter venting	1,2,3		V	
7—Eliminate grinding parting line surfaces (by others)	1,2,3			V
8—Produce the entire cope or drag core on the core-blower (May blow cope and drag together)	1,2,3			V
CLASS 3—Process				
1—Have core finishing (core wash, scab nails, etc.) performed by others (who will also finish for a group of core-makers.)	1,2			V
2—Spray core in place of using swab to save time	1,2			V
3—Revise core box to eliminate split bushing loose pieces	1,2		V	
4—Revise core box to eliminate hand removal of sand from ends of two shank loose pieces	1,2		V	
5—Revise sand delivery equipment, install sand hoppers and chop gates to deliver sand mechanically to core box (too costly)				V
6—Use specially designed air ram in tucking two shank loose pieces. This would eliminate arduous tucking with fingers and tool (not enough clearance)	1,2			V
CLASS 2—Tools, Workplace and Equipment				
1—Locate rod rack at left side of sand bin to hold long straight rods and prebent 14-inch rods. This would eliminate waste "get" motions from rack behind	1		V	
2—Revise open position of core plate clamp to eliminate waste strike-off motions	1		V	
3—Relocate draw lever to enable using both hands in operation of draw (R.H.) and clamp and vibrator (L.H.)	1		V	
4—Eliminate hinged sand delivery apron and revise core box to eliminate open and close motions	1		V	
5—Mechanize clamp, vibrate and draw controls (over-mechanizing)	1			V
6—Use light angle strike-off bar for easier handling and cost saving (not practical—need heavy bar)	1			V
7—Eliminate use of gutter vent template	1		V	
8—Install larger vibrator to speed up draw	1		V	
9—Connect two shank loose pieces together to simplify draw and positioning motions	1			V
CLASS 1—Hand and Body Motions				
1—Tuck lightener pin with L.H. while R.H. tucks lock piece			V	
2—Peen entire core at one time (before rod placement) to eliminate get and disposal rammer			V	
3—Get and position two shank 6-inch nails using both hands			V	
4—Produce entire core in its normal steps to eliminate walking			V	
5—Eliminate strike-off after gutter vent and perform during strike-off of bedding sand (if bedding sand is found necessary)			V	
6—Return ⅛-inch vent tool to rack at base of machine with L.H. while R.H. operates vibrator lever			V	
7—Eliminate brushing sand off of two shank loose pieces			V	

of the production equipment could have sat down and evaluated the desirability of the designs before the equipment was ever built. With present motion and time study techniques it would have been possible to arrive at the suggested methods developed at this plant prior to the installation of any method. The group who worked on the draw-bar core are ready to do this in the future.

Rapidly changing market conditions make it imperative that all people in a plant concerned with the production of products be able to sit down and systematically exchange information to arrive at a setup approaching the most economical method of

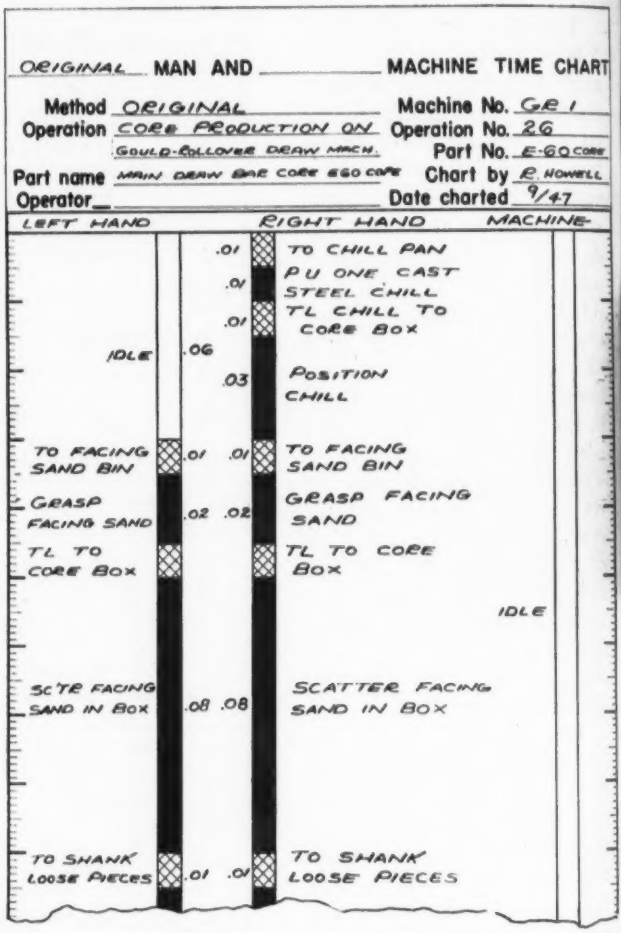

ORIGINAL MAN AND MACHINE TIME CHART
Method ORIGINAL
Machine No. GR 1
Operation CORE PRODUCTION ON
Operation No. 26
GOULD-ROLLOVER DRAW MACH.
Part No. E-60 CORE
Part name MAIN DRAW BAR CORE E60 CORE
Chart by P. HOWELL
Operator
Date charted 9/47
LEFT HAND
RIGHT HAND
MACHINE
.01 TO CHILL PAN
.01 PU ONE CAST STEEL CHILL
.01 TL CHILL TO CORE BOX
IDLE .06
.03 POSITION CHILL
TO FACING SAND BIN .01 .01 TO FACING SAND BIN
GRASP FACING SAND .02 .02 GRASP FACING SAND
TL TO CORE BOX TL TO CORE BOX
IDLE
SC'TR FACING SAND IN BOX .08 .08 SCATTER FACING SAND IN BOX
TO SHANK LOOSE PIECES .01 .01 TO SHANK LOOSE PIECES

Fig. 6—Section of original right and left-hand operation time chart for the E-60 cores

production prior to the inception of production. It is only through a complete understanding of all of the factors affecting the cost of production and the complete integrated participation of all those concerned, that such results will ever be achieved. Motion and time study provides the necessary tools.

Since the designer of factory production equipment plays such an important part in this program it would indeed appear desirable that he obtain, at his earliest opportunity, a complete knowledge of the techniques of motion and time study which make possible the broad integrated approach to the problem of arriving at the most effective and economical method of production.

Redesigning to Withstand Shock

High-speed movies hold key to analysis of mechanisms

By D. L. Pierce
Engineering Section Manager
Control Division
Westinghouse Electric Corp.
East Pittsburgh, Pa.

MOVING pictures of shock tests enable engineers to analyze mechanical movements during and after impact. Using this method, they have been able to modify electrical control devices, such as contactors, relays and resistors to withstand the force of a 2000 foot-pound blow and still function, *Fig.* 1. During the early part of World War II, prior to the development of shock-resisting electrical control devices, many a naval vessel experienced difficulties after an air raid because of the opening of electrical circuits due to the failure of breakers, contactors, relays or resistors. These failures were

Fig. 1—Top—Assembled edgewound resistor and two designs of ceramic insulating sections. The four sections that form a curved line between the hands are the result of this research. Note their rounded ends and shorter sections as compared to the square-ended, longer section of the older design of ceramic core

caused by frames bending out of shape or by insulation cracking and breaking.

To overcome the frailties of Navy and standard industrial electrical control devices for naval service, it was felt a study should be made of the reactions of the component parts to high shock. As it turned out, this study necessitated the use of two unusual pieces of test equipment: A machine for imparting blows of varying severity to the devices and a movie camera for recording the oscillations of the component parts at impact and immediately afterward. The shock test machine had to be developed and built and, although the camera was available, lights of sufficient intensity had to be designed and built. As a result, a considerable amount of experimentation was required before satisfactory pictures were made.

Remain in Position after Impact

From laboratory tests it was decided that control devices for shipboard service should withstand a mechanical impact of 2000 foot-pounds without permanent distortion to or breakage of a single component part. In addition, the device should remain in its original electrical position during test. This meant for example, that if a contactor was closed for the shock test it must remain so during and after impact. Conversely, if a contactor was open for the shock test it must remain so during and after impact.

It was decided that the shock test machine must deliver three distinct types of blows: A vertical top blow, a horizontal side blow and a horizontal rear blow.

The test machine, *Fig.* 2, built for this research is made up of four principal members: A vertical structure, a striking plate, and two hammers. The vertical structure is made of angle iron pieces and is about fifteen feet high. The striking plate is a three-foot square, heavily reinforced steel plate. The hammers each weigh 400 pounds. One slides vertically inside the guides formed by two T-beams. The other swings in an arc at the end of a 5-foot arm.

To permit horizontal movement resulting from a horizontal rear blow, the striking plate is bolted loosely to the face of the shock stand with four bolts and eight coil springs. Four of the springs are placed between the striking plate and the face of the two vertical angle iron members. The other four are placed inside the angle iron members. To permit vertical movement resulting from a vertical top blow, the striking plate is supported at the base of the shock stand with two half-elliptical truck springs. These are attached to the base with clamps and shackles.

Control devices to be tested are bolted to a ½-inch thick steel plate that in turn is bolted to the striking plate through two four-inch channel irons, one down each side. To impart a vertical top blow, the 400-pound hammer is raised the desired height above the striking plate (5-feet for a 2000-foot-pound blow) and allowed to drop. It strikes the top edge of the striking plate and a vertical top blow results. To impart a horizontal rear or side blow, the second 400-pound hammer, the one that swings in an arc, is raised the desired height and allowed to fall. When the striking plate is bolted to the face of the shock stand the hammer strikes the rear and a horizontal rear blow

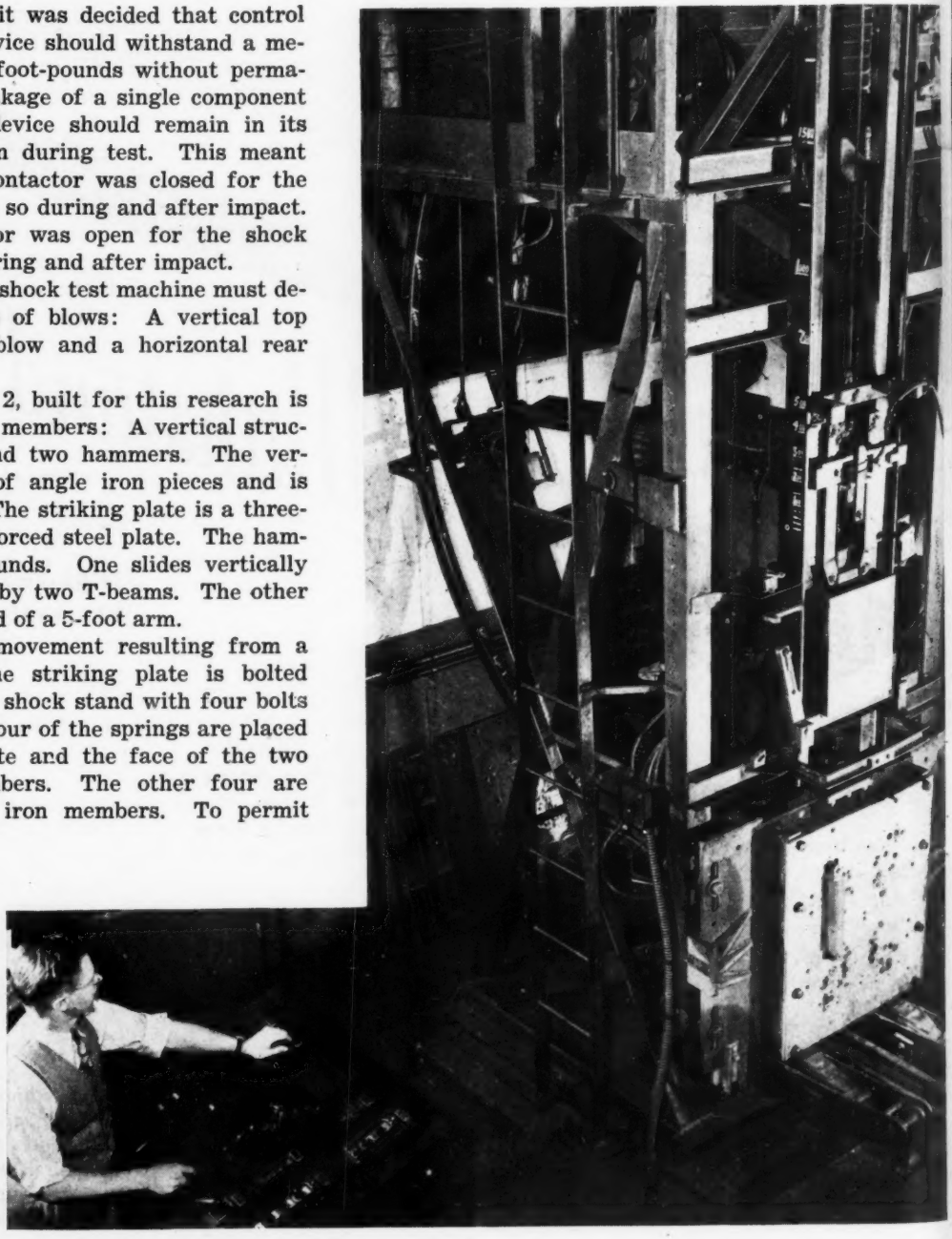


Fig. 2—Edgewound resistor being subjected to 1000 foot-pound shock. The 400-pound hammer that strikes the horizontal rear and side blow is in the raised position. A twist of the control lever in the operator's right hand will release the hammer allowing it to fall and strike the plate

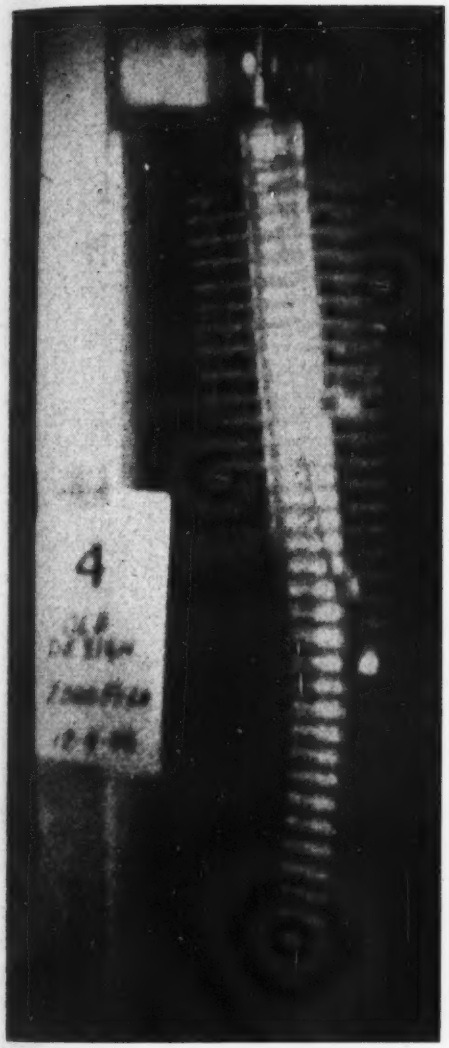


Fig. 3—Left—Frame from high-speed film showing effect of impact on edgewound resistor with square-ended ceramic sections. This view was taken during impact. The resistor is bent as a result of the blow, breaking into fragments

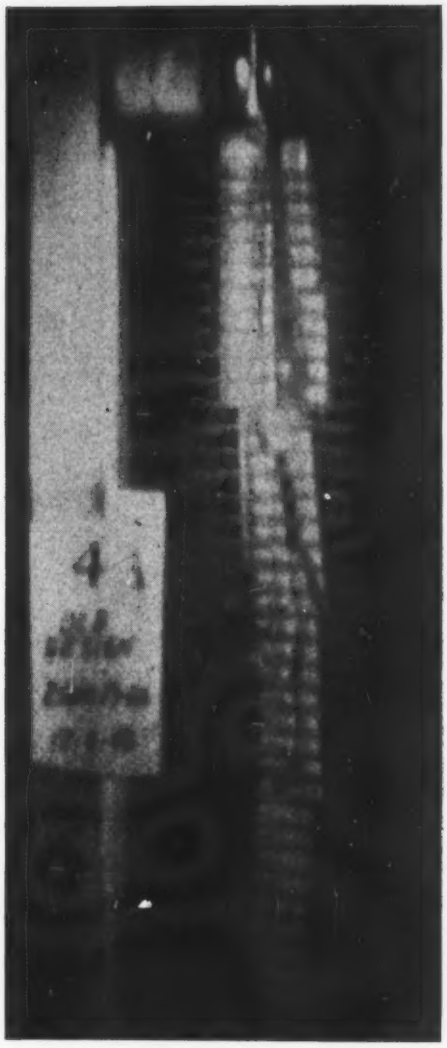


Fig. 4 — Right — Frame from high-speed film showing effect of impact on edgewound resistor with square-ended ceramic sections. This view was taken after impact. Ceramic sections have split lengthwise and opened

results. When the striking plate is unbolted from the face of the shock stand and rotated 90 degrees the hammer strikes the side edge and a horizontal side blow results.

It was soon discovered that, without the aid of the high-speed camera, it was impossible to predict the results of a 2000 foot-pound blow beyond the fact that it would usually demolish the test specimen. The many frequencies of oscillation that resulted from the impact contributed as much to the unpredictability of the test as the original blow.

Heavier Parts Aggravated Situation

Various attempts to strengthen component parts by making them heavier only complicated the situation. This for three main reasons: The increased mass changed the natural frequency of vibration and this usually resulted in losses rather than gains; the added weight often resulted in bending and even breaking parts that had previously withstood the blow successfully; and, the increased rigidity transmitted more force to certain integral parts that resulted in breakage not previously experienced.

Effectiveness of high-speed movies, using 2000 frames per second can be adjudged by a study of *Figs.* 3, 4, 5 and 6. These are prints from selected frames of one of the many films made of shock tests on edgewound resistors. *Fig.* 1 gives clearer conception of the construction of the edgewound resistor. The central core of the resistor (above hands) is a steel bar ⅛-inch thick by 1¼ inches wide. Around this steel bar core, which has first been covered with asbestos paper, is placed the molded ceramic insulator sections shown in the bottom of the photograph. The insulator sections are made in short lengths with a lengthwise groove down the center of the inside that is slightly wider than the steel bar is thick. It takes four pairs of two sections back-to-back to cover the steel bar (eight pair of the modified sections). Around the ceramic insulators the resistance ribbon is wound edgewise. Electrical connections are made at each end and at a midway point. The notches at each end of the steel bar core are used to mechanically mount the resistor to the control board. As this is customarily done in a vertical position with respect to the length, the resistors were mounted in this position for all shock tests.

Reveals Weakness in Design

Careful study of *Figs.* 3 and 4, the former made during impact and the latter afterward, reveals some interesting weaknesses in this industrial control device for high-shock duty. As can be seen in *Fig.* 3,

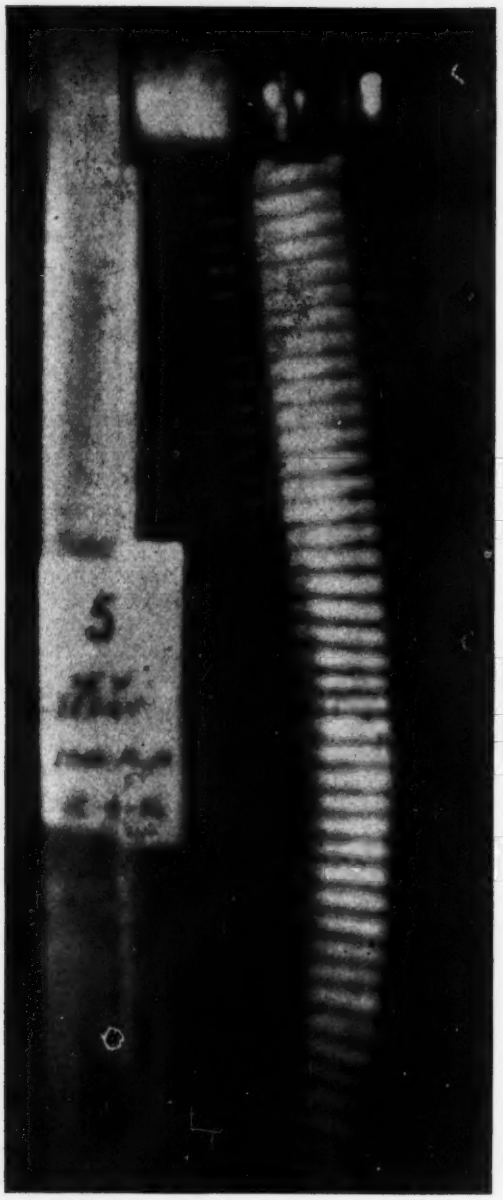


Fig. 5—Left—Same as Fig. 3 but with round-ended ceramic sections. There is no evidence of chipping or breaking of the ceramic insulator sections

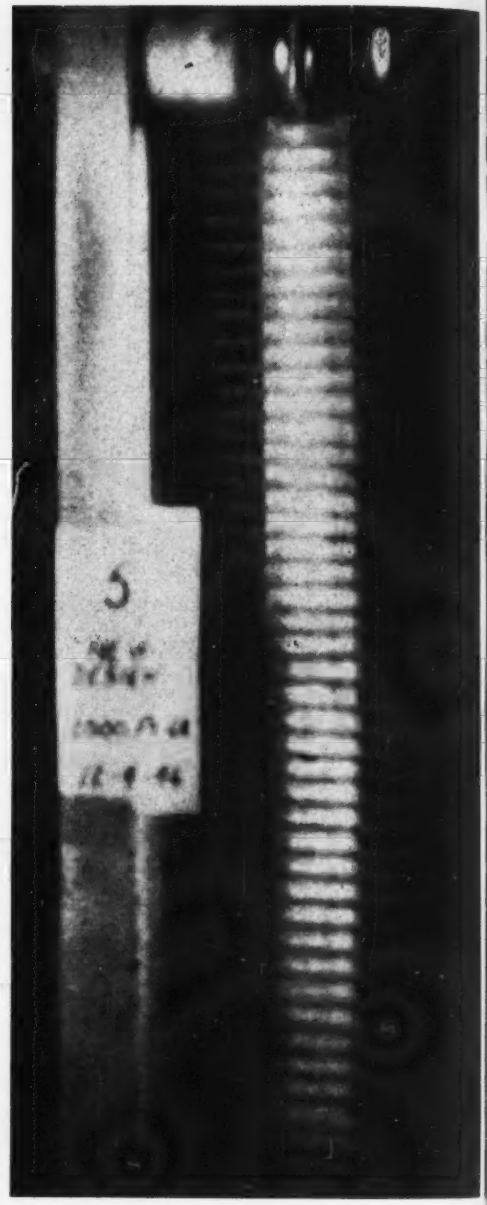


Fig. 6—Right—Same as Fig. 4 but with round-ended ceramic sections. Even after impact there is still no evidence of chipping or breaking of ceramic insulators

the whole resistor has been bent considerably as a result of the 2000 foot-pound impact. This bending caused the ceramic section to chip off near the ends and to split lengthwise. In *Fig.* 4, the full effect of the impact and oscillations that followed is evidenced by the completely severed and broken ceramic sections.

Heavier Parts Do Not Help

To overcome the breaking of insulator sections under impact, several rather obvious structural changes were tried before the answer was found. The first was to use a heavier steel bar core. When this failed to produce the desired result, a cushion mounting was tried. When these two failed, individually and in combination, a center support was added. This too failed to correct the one weakness of the resistor under high shock: cracking and breaking of insulator sections.

Further study was then made of the films and it was noticed for the first time that the breaking of the ceramic sections always started at the inside ends of the individual sections even though after shock the complete insulator would be broken. This was apparently due to compression forces on the inside of the bend. The severity of the bending, as shown in *Fig.* 3, was so great that it was impossible for the ceramic sections to take this much curvature without breaking at the ends due to the fact that they were square. To correct this, new insulator sections were designed. Four of these are shown between the two hands in *Fig.* 1. These are one-half the length of the older sections and are radiused on the ends so they can stand a considerable amount of steel bar curvature without being subjected to a compressive force that would crush and crack them. This simple change in design corrected the breakage trouble. *Fig.* 5 shows a resistor with the modified insulator sections during shock and *Fig.* 6 afterward. Even though there is extensive bending of the resistor in *Fig.* 5, there was no chippage or breakage or damage as can be seen in *Fig.* 6.

Another device on which the high-speed movie camera was used to analyze what happened during high shock was a 2-pole, 50-ampere, d-c contactor. A side view of a redesigned contactor, with the left-hand contacts and the arc box removed, is shown in *Fig.* 7.

Latch Mechanism Failed

When the original design of contactor was subjected to high shock, the component parts were either bent out of shape or otherwise damaged to the extent that it repeatedly failed. If the armature was closed at the start of the shock test, it would be open afterward. Conversely, if the armature was open at the start, it would be closed following impact. The latch design, the latch weight and springing were changed and modified many times. Several modifications were made in the latch tongue, but there resulted no noticeable improvement in performance under high shock.

High-speed movies disclosed that, what had seemed unlikely to happen actually did happen, the frame was bending up and down fully one-half inch during impact. When a shock test was made on a contactor in the closed position, the armature tongue was pulled out of engagement with the latch, due to the springing of the frame, and the armature flew open. This accounted for the tongue showing marks of engagement with the latch yet not remaining in position throughout the impact test.

The frame was then braced at the corner with a plate as shown in *Fig.* 7. One such plate was spot welded to each side of the frame. These stiffened the frame sufficiently to eliminate most of the bending. Following this structural change another series of high-speed movies were taken. These showed that when a shock test was made on a contactor in the closed position the latch stayed engaged with the armature tongue during and after the shock and, as a result, the armature remained in the closed position.

Study of *Fig.* 7 will explain why this is so. As the inertia weight pivots around a fixed pivot any shock or rapid acceleration of the contactor causes the weight to rotate in an up or down direction. Regardless of direction of rotation the weight forces the latch down. If the armature is in the closed position, it will remain closed because the force of the inertia weight during and following impact will keep the latch down, thereby holding the armature in the closed position.

If, on the other hand, the armature is in the open position, as in *Fig.* 8, and the force of an impact is such that it would rotate the armature to the closed position, the way will be blocked. This is for the

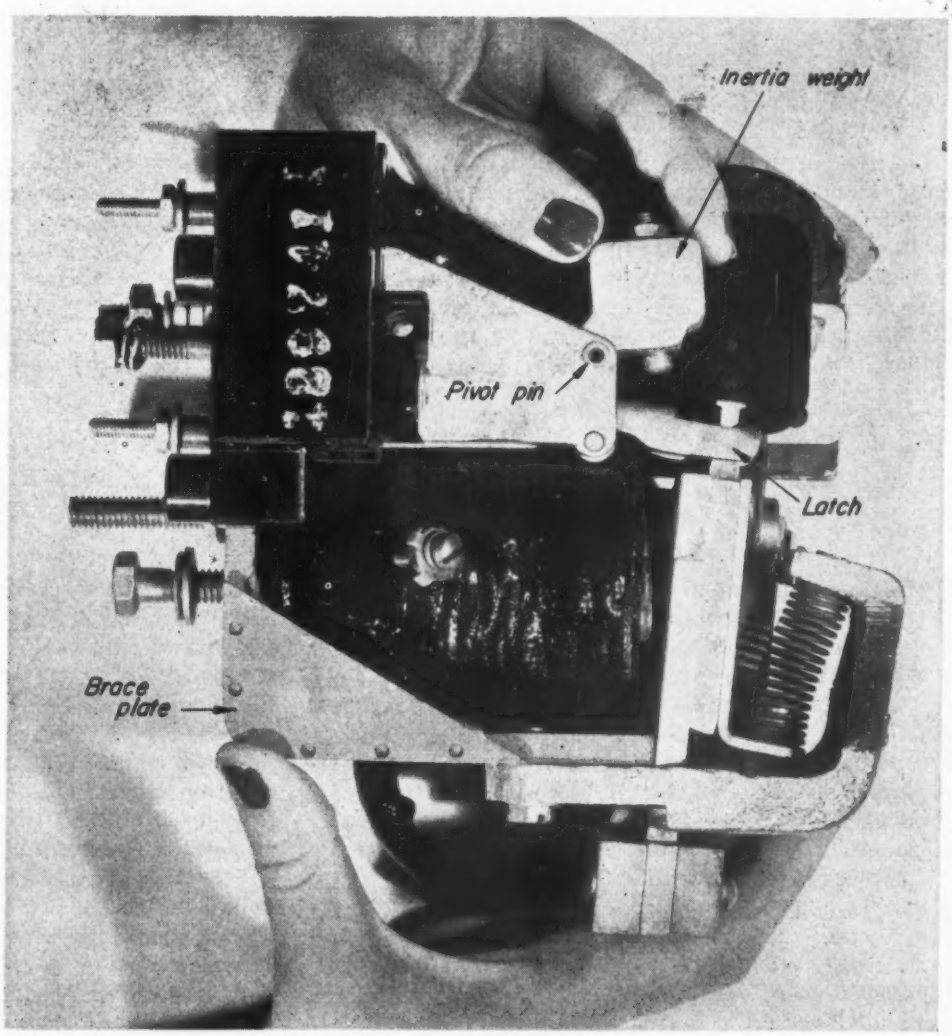


Fig. 7—Contactor with armature in closed position. Inertia weight is in up position. As a result, latch has been forced down on armature tongue

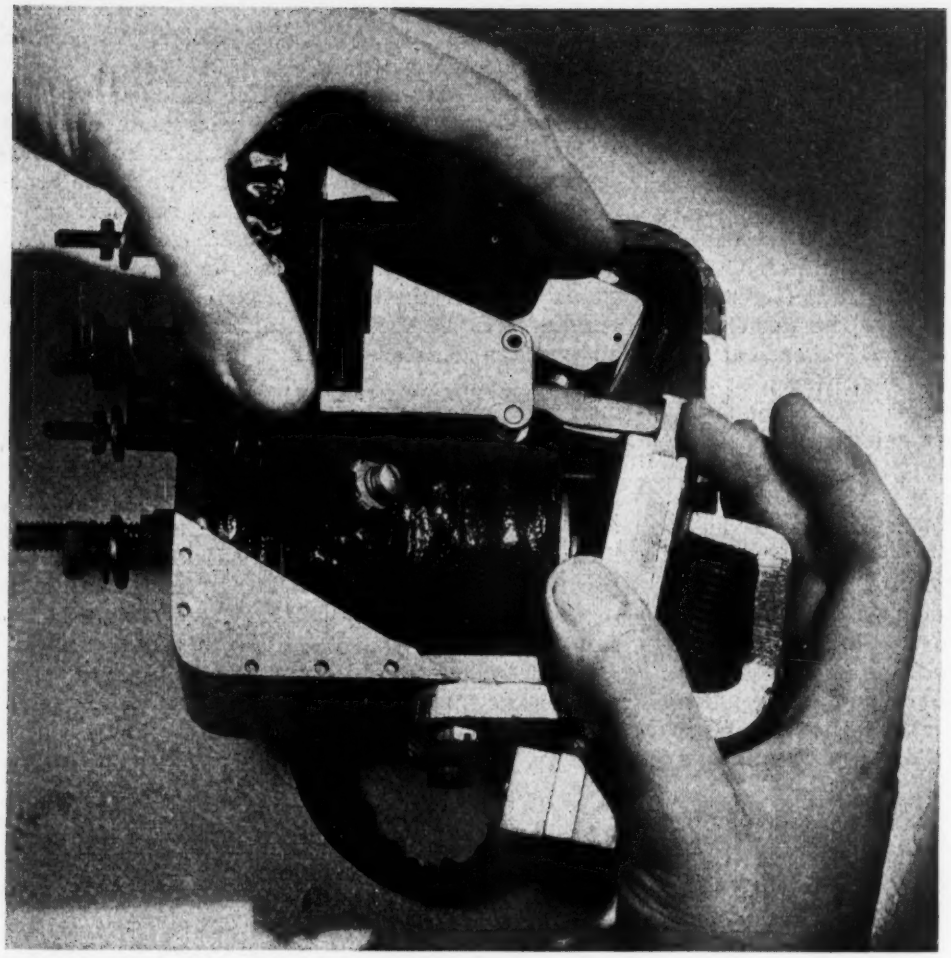


Fig. 8—Contactor with armature blocked in open position. Inertia weight is in down position. As a result, latch has been forced down. This blocks armature from closing as the tongue strikes the end of the latch

reason that the same blow will have forced the inertia weight down (or up) and it in turn will have forced the latch down below the top of the latch tongue of the armature. Therefore, the latch tongue strikes the end of the latch and the armature rebounds to the open position.

These two case studies serve only to illustrate the effectiveness of high-speed movies as a research tool. Such diverse matters as electric arcs and mechanical action of contactors and circuit breakers opening and closing under normal action have also been investigated thoroughly. As a result, a great deal has been learned about the action of electric arcs and the resulting effect upon contact surfaces.

Instruments Insure Economical Operation

POWER consumption and speed of various units in a machine must be easily and quickly determined by the operator to obtain the most from any motorized production. To enable him to evaluate these conditions at all times, the indicating instruments must be placed at the point from which the machine is operated. Increasing demands for such instrumentation are being met by the designers of production machines, according to Roy J. Teetsell, instrument specialist for Westinghouse Electric Corp.

Another important reason for the use of instruments is due to the constant effort to reduce unit labor costs. Instrumentation fits hand in hand with the trend, since its use minimizes the requirements for skilled operators by removing the human element variable from the operation to a large degree. Although skilled operators perform creditably with but little instrumentation, they can do a more efficient job with adequate instruments. Often semiskilled men can perform the same job just as well because the instruments can supply that which the operators may lack in experience. The overall result is a speed-up of production. Furthermore, instruments serve as a ready indication as to whether or not the machine is being used at its maximum utility and if the loads imposed are well within the capacity of the machine.

Switchboard instruments have an accuracy of plus or minus one per cent and panel instruments of plus or minus two per cent. In selecting the capacity of an instrument it is well to keep the indication of the pointer between ½ and 2/3 scale for best accuracy and readability under normal conditions.

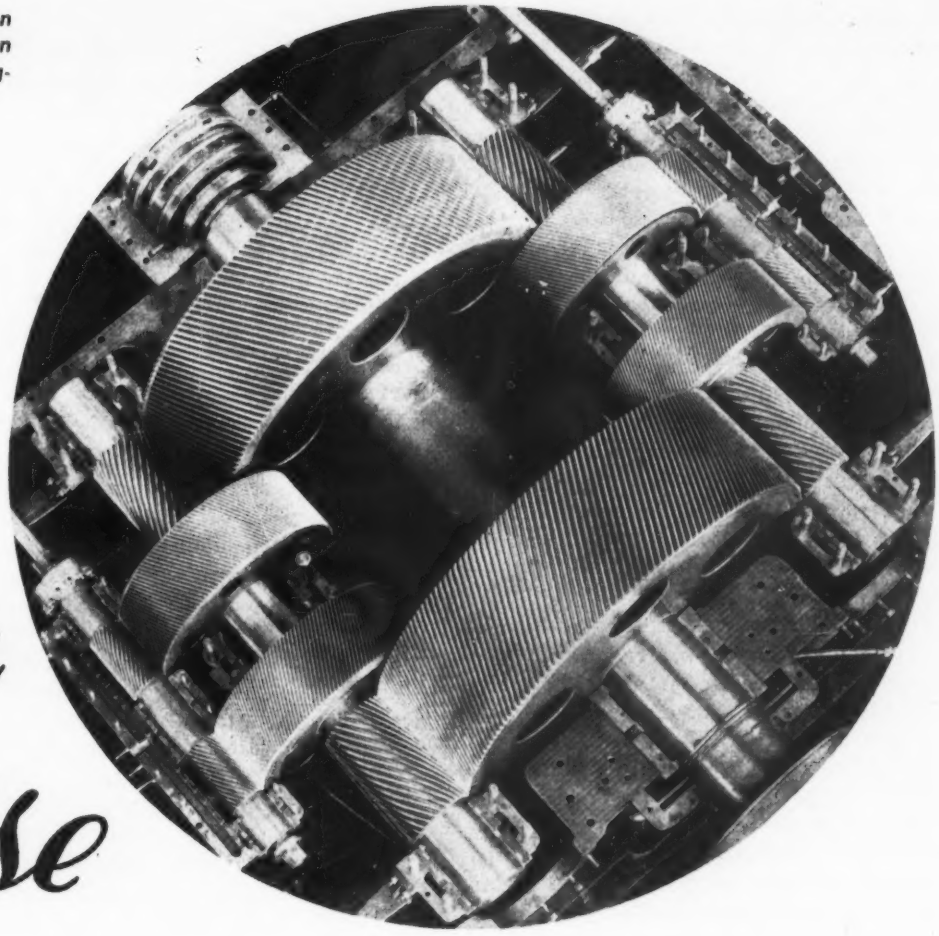


Fig. 1 — Typical double-reduction gear set for marine propulsion drive. Photo, courtesy Westinghouse Electric Corp.

Gear noise

... exposes naval ships to detection by the enemy. How the problem is being attacked is discussed in this abstract of a recent AGMA paper

By George Wohlberg

Superintendent, Wave Mechanics Laboratory
U. S. Naval Engineering Experiment Station
Annapolis, Md.

IN recognition of its importance, the machinery noise problem is currently the subject of a large-scale attack by the Navy. The reduction of gear noise is one of its principal objectives. The program is intended to assist the gear industry to meet Naval noise requirements by providing usable engineering information concerning gear noise. It should provide the basis for enforceable noise specifications aimed at reducing noise below the level of military liability, as well as means for estimating the service noise levels of gears prior to their installation in ships.

Sound may be measured in terms of any of the several parameters which define the motion or energy of the molecules of the medium through which it is transmitted. These parameters are intensity, sound pressure, vibratory velocity, vibratory acceleration, vibratory excursion (displacement) and frequency. The most commonly-used parameters are sound intensity, sound pressure and frequency.

Sound is commonly measured on a logarithmic scale whose unit is the decibel. As a unit of measure, the decibel is unusual in that it is the logarithm of a ratio, instead of being a uniform linear unit like most other units used in engineering and scientific work. It is to be emphasized that since decibels are essentially ratios, sound levels expressed in decibels corresponding to a given intensity or pressure depend for their numerical values on the particular reference intensity or reference pressure used. The American standard reference intensity corresponds to the

threshold sensitivity of the human ear to a reference sound having a frequency of 1000 cycles per second.

Several practical reasons dictate the use of a unit such as the decibel. One is that the human ear is a logarithmic type organ, in that the sensation of hearing is roughly proportional to the logarithm of the stimulus. Another is that the smallest difference in sound level the ear can perceive is approximately 1 db. A third reason is connected with the fact that the ear responds to an enormous range of sound intensity. Considering the useful range of hearing to lie between the threshold of perception and the threshold of pain, the ratio of sound intensities over this range is 1,000,000,000,000 to 1. As shown in TABLE I, this range represents 120 db. It is evident that through the use of the decibel scale this range can be expressed in terms of readily comprehensible small numerical values.

Frequency Affects Ear Response

The evaluation of sound in terms of ear perception of loudness entails several complications. One of these is the fact that the ear is not only pressure-sensitive, but is also frequency-sensitive. Its frequency sensitivity depends in a nonuniform manner on the pressure level considered. At sound levels between 0 and 90 db, the ear sensitivity tends to increase with frequency up to about 3000 to 4000 cps. At sound levels about 90 db, the sensitivity tends to become uniform with respect to frequency so that both low and high frequencies are given nearly equal weight as far as loudness is concerned.

In naval applications, where ship noise is primarily important from the standpoint of detection by the enemy through use of sonar listening, the frequency response characteristics of sonar apparatus must be considered in evaluating the relative importance of sounds of various frequencies and levels. Instrumental methods of listening can compensate for the tendency of the human ear to discriminate against low-frequency sounds at relatively low levels, as well as against high-frequency sounds above 4000 cps. For this reason, in cases where noise is of military concern, even those sounds which the ear ordinarily discounts can be of considerable significance. In other words, the so-called "inaudible noises" are still a problem in the gears of naval ships.

TABLE I
Sound Intensity and Intensity Level

Sound Intensity Ratio (I/I_o)	Sound Level in Decibels (db)
1	0
10	10
100	20
1,000	30
10,000	40
100,000	50
1,000,000	60
10,000,000	70
100,000,000	80
1,000,000,000	90
10,000,000,000	100
100,000,000,000	110
1,000,000,000,000	120

GENERATION OF NOISE IN GEARS: In classifying the influences involved in the generation of gear noise, it may be useful to resort to a medical analogy. In medicine, diseases are sometimes classified as to origin as being either congenital or acquired. This distinction might also be applied to gears. The "congenital" sources of noise in gears may be defined as those which originate from errors characteristic of the machines or methods used for manufacturing the rotating elements in gearing, as well as those which are inherent in gears by virtue of design or properties of materials. The "acquired" sources of noise are those which depend for their origin on the conditions of application, such as mounting, internal and external alignment, case flexibility, torsional vibration, etc. Of the two types of sources, the former are probably the most troublesome from the standpoint of susceptibility to control.

A partial list of sources of noise in gears follows, using the system of classification suggested. The order of listing is not intended to suggest order of importance.

Congenital Sources of Noise

1. *Due to manufacturing imperfections*
   (a) Errors due to master worm wheel inaccuracies
   (b) Errors impressed on master worm wheels by the parent master worm wheels
   (c) Tooth-contact frequencies of master worm wheels
   (d) Errors due to worm inaccuracies
   (e) Feed-screw errors
   (f) Tooth-form imperfections

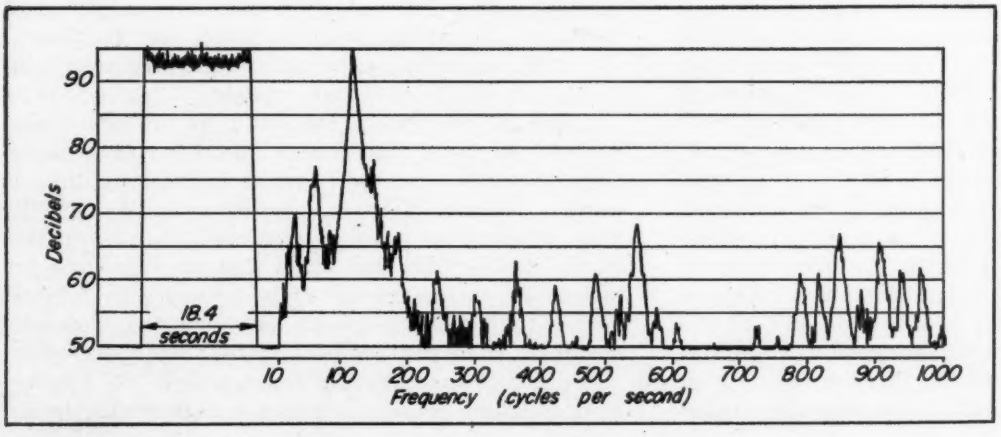


Fig. 2 — Machine noise spectrum obtained with autographically recording sound frequency analyzer. Record at left represents overall noise level

(g) Tooth-spacing imperfections
(h) Helicity imperfections
(i) Tooth-finish imperfections

2. *Due to design and properties of materials used in rotating elements of gearing*
(a) Tooth-contact frequencies due to tooth engagement and vibration
(b) Radial, axial and tangential modes of vibration of gears and pinions due to components of force acting in these directions
(c) Journal deflections of rotating elements
(d) Resonant vibrations of rotating elements
(e) Sliding tooth contact, as distinguished from rolling contract

"Acquired" Sources of Noise

1. Gear case resonance
2. Sub-base resonance
3. Internal misalignment of rotating elements
4. External misalignment with connected shafting and machinery
5. Interference between pinion and gear helices in herringbone and double-helical gears due to externally-applied axial thrust
6. Torsional vibration of mass-elastic systems of which gearing is a part
7. Noises due to couplings.

Noise is produced by vibration. Vibrations in gears may be induced in several ways. Imperfections of tooth spacing and form produce minute variations of angular velocity of the rotating elements. These accelerations are associated with forces which produce vibration. However, even gears with theoretically perfect tooth spacing and form would produce some noise due to tooth engagement. As teeth come into mesh and become loaded they deflect. At disengagement, the teeth are relieved of load, and a vibration occurs. The elasticity of the materials and their generally low internal damping properties are conducive to the maintenance of vibration.

Misalignment of rotating elements produced by either internal or external causes also results in noise. By causing load concentration on portions of teeth and tending to interfere with smoothness of meshing, misalignment produces vibration and, hence, noise.

The vibratory forces induced by tooth action result in so called forced vibrations. These forces may be resolved into tangential, radial and axial components. Each of these components of force can excite one of the many natural modes of vibration of the rotating elements, of the gear case, and of the foundation. Whenever the frequency of a forced vibration approaches closely or coincides with the frequency of a natural mode, resonance occurs with a consequent large increase in noise level. The magnitude of the increase depends on the damping present in the system; the greater the damping the less the amplitude at resonance.

Vibrations and sound produced by the action of the rotating elements are transmitted through the journals into the bearings, and thence into the gear casing. Excitation of the gear casing by sound transmitted through the air in the gear case may also cause the latter to vibrate. Usually, although the gear case is only a secondary source of noise, it is actually the direct source as far as radiated or transmitted noise is concerned. This is particularly true when there are no vents, or only small vents, in the gear case through which air-borne noise can directly escape from the gear mesh. The gear cases and subbases of gears are important from the standpoint of noise in that they modify and often amplify the noise of the rotary elements proper.

GEAR NOISE REDUCTION: Broadly speaking, there are two general types of noise reduction methods—those which affect the source of noise directly and those which act indirectly by reducing the acoustic response of the environment of the source. These methods will be discussed briefly in general terms. The applicability of any of these methods to particular cases can be determined only through careful diagnosis of the specific mechanical actions which produce noises. Much time and money can be spent on noise reduction efforts, without tangible results, if noise reduction expedients are applied more with hope than with understanding of the fundamental causes of noise in particular cases.

Following is a brief summary of some of the methods of noise reduction which are potentially applicable to gear noise:

Manufacturing Accuracy. This is regarded as the most important basic noise reduction measure as it reduces the magnitude of the exciting forces which produce noise, thereby minimizing the need for the application of additional noise reduction measures. Geometrical accuracy of the rotating elements and the accuracy of internal alignment of the elements are involved.

Damping Effective Only at Resonance

Damping. Whenever resonance is indicated as the cause of high noise levels, the use of damping will produce worthwhile reduction noise. Otherwise, damping will produce little acoustic effect. The effectiveness of damping for noise reduction depends on the vibratory force doing work. The work done is greatest at resonance.

Radiation Resistance Mismatch. By causing sound to be transmitted through a series of different substances whose acoustic radiation resistances are unequal, sound attenuation can be obtained. Radiation resistance is the product of the density of the medium and the velocity of sound propagation therein. The larger the ratio of radiation resistances, the greater is the attenuation. For example, a ratio of 10:1 of radiation resistances of two contiguous media produces a transmission loss of approximately 33 per cent.

Natural Frequency Shifts. Whenever resonance is a principal cause of excessive noise, shifting the natural frequencies of vibratory systems above the exciting frequencies can reduce noise. Stiffening of gear cases for noise reduction purposes is an example of this. Lowering of operating frequencies also can be resorted to for elimination of resonances. These methods are often not practical for noise reduction on propulsion gears. The many frequency components present in gear noise spectra, *Fig.* 2,

usually do not permit sufficient frequency shifts to avoid all resonances.

Dynamic Absorbers. The addition of a small tuned system to a main vibratory system can also reduce vibration. This method might find limited usefulness in the reduction of noise on gears for fixed-speed service. It appears to be of limited utility as far as propulsion gears are concerned.

Counterphasing. The neutralization of vibration by operating two identical sources 180 degrees out of phase is a possibility for noise reduction in special cases. It is usually difficult to achieve this phase relation in practical cases involving gears. This also is not a generally promising method for gear noise reduction.

Reduction of Sound Radiating Area. The airborne sound output of a gear can be reduced by reducing the areas of sound radiating surfaces. The extent to which this can be carried is usually rather limited as far as the gear case is concerned. Whenever a large surface, such as a ship's hull plating, is excited by gear vibration, appreciable noise reduction could probably be obtained if the mechanical contact between the hull and the gear could be greatly diminished. Planetary reduction gears appear to be particularly susceptible to the use of this method. The use of vibration and sound isolators would be indicated with such gears.

TABLE II

Significance of Various Degrees of Noise Reduction

Noise Level Reduction (db)	Sound Intensity Reduction (per cent)	Comment
3	50	Perceptible effect; does not warrant more than minor experditure
5	68	Distinctly noticeable improvement; worth moderate experditure
10	90	Very pronounced improvement; worth considerable expense
20	99	Startling improvement; sounds as if source nearly stopped; worth what it costs, if this degree of quieting is necessary

Dynamic Balance. Markedly faulty dynamic balance is seldom found in well-made gears. If present, however, it can cause considerable noise. The remedy is obvious.

Acoustic Enclosure. If reduction of air-borne noise is the only objective of noise reduction efforts, acoustic enclosure of gears by means of solid metallic hoods, lined with sound absorbing materials, is an effective noise reducing measure. This method is, of course, ineffective for reducing underwater noise radiated by a ship excited by a rigidly mounted gear.

Necessity for proper diagnosis of the cause of noise and the selection of appropriate remedies was previously mentioned. As an example, the author was required during World War II to quieten certain extremely noisy propulsion gears after they had already been installed in several Naval vessels. Time was extremely short, a little more than one week, in fact. Analysis showed that a noise component associated with a master worm-wheel error was the primary cause of excessive noise. This finding apparently indicated that the way to reduce the noise was to refinish the gears. As this would have delayed the ships for several months, it was impracticable.

Fortunately, a quick investigation disclosed that resonant vibration of the gear case excited by the tooth error frequency was the direct cause of excessive noise. This suggested that noise reduction could be achieved by suppressing the resonant vibrations of the gear case, instead of removing the rotating elements and refinishing them. An acoustic treatment was developed on the spot for this purpose. Noise intensity reductions ranging from 81 to 99 per cent were obtained at the formerly noisiest operating speed. The ships involved were able to proceed on their wartime missions without loss of time. The overall cost was far less than refinishing of the rotating elements would have entailed.

One of the problems confronting engineers on noise reduction work is to determine the extent of attenuation required to meet specific needs. It makes a very considerable difference in cost whether a 5-db, 10-db or 20-db noise reduction is sought. Whereas a 5-db, or even a 10-db, reduction sometimes might be achieved by relatively inexpensive modifications, a 20-db reduction is such a large effect that considerable basic redesign of the machine is likely to be necessary to realize it. Therefore, the requirements of the application should be considered in order that noise reduction be neither economically excessive nor inadequate. The rough scale of values shown in TABLE II affords a guide as to the significance of various degrees of noise reduction.

Criterion Is Inaudibility to Enemy

In Naval practice, economic considerations do not necessarily determine the extent of noise reduction desired, nor its value. The considerations that apply are how much reduction is necessary to make conditions satisfactory for ship handling and crew comfort, and to render noise inaudible to the enemy. The latter is the more basic criterion. Assuming that a certain sound component predominates, the degree of noise reduction necessary to render it undetectable is the amount necessary to reduce its level by about 6 db below the level of the next highest component. Reduction below the background noise level at a given frequency is necessary to render noises undetectable in many cases. In some cases, masking effects must be considered in determining the amount of noise reduction required for specific purposes. The military importance of noise reduction is apparent from the fact that the audibility distances of sounds in the sea are diminished by about half for each 6-db reduction in pressure level.

EFFECTS OF ENVIRONMENT ON GEAR NOISE: Noise presents an unusually troublesome engineering measurement problem in that sound measurements include not only the acoustic effect of the noise source but also the acoustic response of its environment. Noise measurements which have for their objectives the prediction of gear noise under service conditions, the accurate diagnosis of causes of noisy operation, or the evalution of the merit of noise reduction measures, should be made under controlled conditions in

which the environment of the gear is not a significant acoustic factor. With respect to this requirement, sound measurements on board ships, in factories and in conventional machinery test laboratories are often made under extremely adverse conditions.

When air-borne or solid-borne sound measurements are attempted under such conditions, the results are often misleading. The principal environmental effects which bring about this result are discussed in the following.

Rooms or spaces of conventional rectangular geometry and having sound reflecting rigid boundaries exhibit a large number of natural modes of vibration. For the sake of simplicity, these might be visualized, to a first approximation, as standing waves similar to those which exist in organ pipes closed at both ends. Each of the dimensions of the room can be represented by an organ pipe of corresponding length.

To illustrate the large number of natural frequencies possible in ordinary rooms, calculation indicates that for a 50 x 40 x 30-ft room there are forty-five natural frequencies possible in the small frequency range extending from 11 to 285 cps.

Room Resonance Confuses Findings

The practical significance of such natural modes in rooms is that resonances are not only possible, but are likely to occur, at many of the frequencies present in the noise spectra of gears. The result is that such frequencies will appear at exaggerated amplitudes and will tend to incriminate the gear as a noise-maker, whereas the room might actually be to blame. The same gear placed in rooms of different dimensions, or even in the same room at different points, will apparently have different noise spectra. The implications of this fact in connection with the specification of limiting noise levels for gears are evident.

Other environmental difficulties, which complicate the measurement of either air-borne or solid-borne noise, arise from sound conduction through shafting, piping and through the ground.

The foregoing effects are especially disturbing when gears are tested by the back-to-back or front-to-front methods. Due to the mechanical identity and close coupling of the two gears involved in such tests, these effects are particularly pronounced, and it is virtually impossible to evaluate reliably the noise of each of the gears independently of that of the other.

NOISE TESTING OF GEARS: As part of its extensive efforts in reduction gear development, the Bureau of Ships of the Navy Department is sponsoring a program of engineering research on gear noise at the U. S. Naval Engineering Experiment Station at Annapolis, Maryland. The initial phase of the indicated program will be carried out on a conventional, twin-pinion single reduction, 2650-hp submarine propulsion gear. The acoustic test set-up for this gear will be typical of others to be used for tests on planetary and other types of gears later. This set-up is unusual in that it achieves a high degree of acoustic isolation of the gear under test from the ambient noise interferences and from the driving and loading machinery. It also permits operation of the gear at any load and speed within its rating, without resorting to "back-to-back" operation. The arrangement of the equipment and the principles of isolation employed are shown on *Fig.* 3.

Some of the shortcomings of conventional spaces in which machinery noise studies are usually made have been pointed out previously. In order to enable the Navy to make a large-scale, intensive effort to reduce machinery noise, a unique acoustical laboratory is now being built. This laboratory is designed specifically to provide a favorable acoustic environment for noise investigations on both main-propulsion and auxiliary machinery of ships.

(*Concluded on Page* 182)

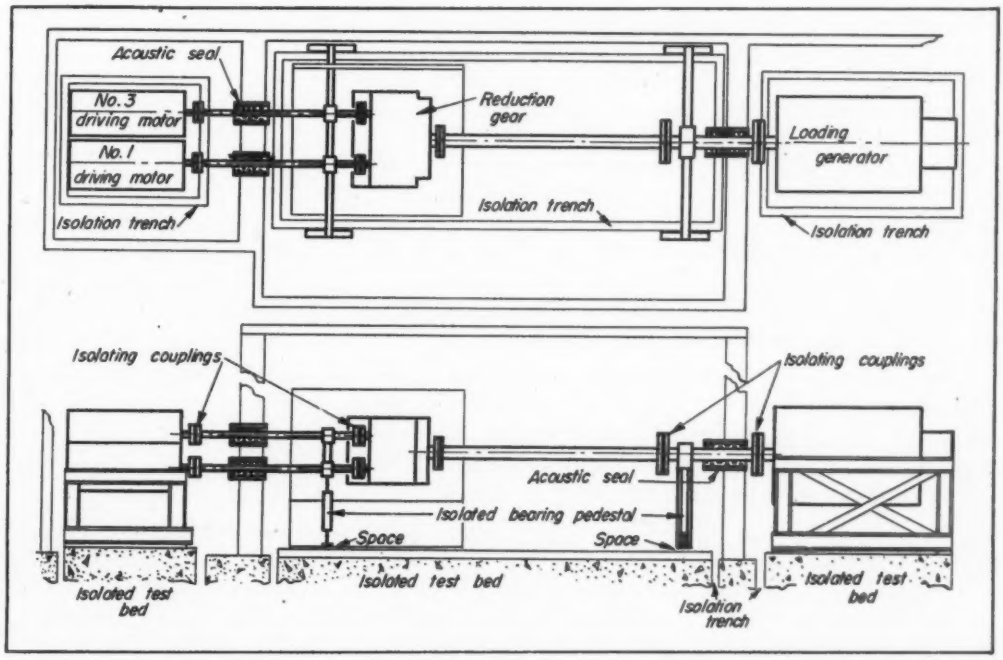
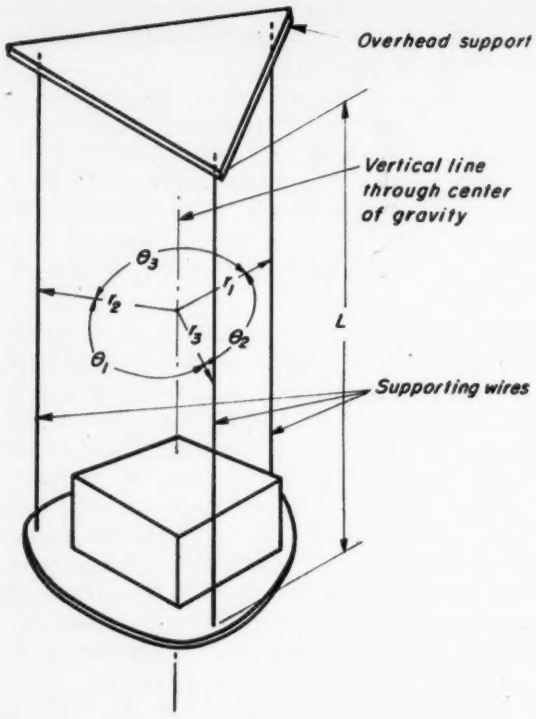


Fig. 3 — Arrangement of equipment for acoustic testing of submarine propulsion gears, showing principles of isolation



Determining Moment of Inertia

By Charles E. Crede

Chief Engineer
The Barry Corporation
Cambridge, Mass.

IT frequently is necessary to know the moment of inertia, or radius of gyration, of a machine or machine part. This information is needed to determine types and locations of vibration mounts, to calculate critical frequencies of machine elements, and for other purposes. An accurate method is to suspend the part in such a manner that it may vibrate torsionally, and measure the period of free vibration.

Technique used at The Barry Corporation is illustrated in the accompanying figure. A plywood platform, essentially triangular in outline, is suspended from an overhead support by means of three equally spaced parallel wires. The body whose moment of inertia is to be determined is set on the platform, preferably with its center of gravity directly above the geometrical center of the platform. It is essential that the axis about which the moment of inertia is to be determined be vertical. This is easily arranged by inserting blocks of proper height between the body and the platform. The platform is then caused to vibrate torsionally with small amplitude about a vertical axis and the period of free vibration measured by a stop-watch or other means.

CALCULATIONS: For the general case, in which a vertical line through the center of gravity of the combined body and platform does not pass through a point equidistant from the three supporting wires, the equation for determining the moment of inertia is

$$I = \frac{Wr_1r_2r_3T^2}{4\pi^2L}\left[\frac{r_1\sin\theta_1 + r_2\sin\theta_2 + r_3\sin\theta_3}{r_2r_3\sin\theta_1 + r_1r_3\sin\theta_2 + r_1r_2\sin\theta_3}\right] \quad (1)$$

where W = weight of combined body and platform, lb; T = period of oscillation, sec; L = length of supporting wires, in.; r = distance from center of gravity to supporting wire, in.; θ = angle between radial lines from center of gravity to supporting wires; and I = moment of inertia of combined body and platform, lb in. sec.^{2}

If the body can be set on the platform in such a manner that its center of gravity lies directly above the geometrical center of the platform, Equation 1 is greatly simplified, as all distances r become equal and all angles θ become equal to 120 degrees. The simplified equation is

$$I = \frac{Wr^2T^2}{4\pi^2L} \quad (2)$$

Values of r and L in Equation 2 are constant for any given installation. In the installation at The Barry Corporation, for example, r = 10 inches and L = 55 inches. Equation 2 is then further simplified as follows:

$$I = 0.0461\ WT^2 \quad (3)$$

It has been determined that the platform alone weighs 3½ lb and that its moment of inertia is 0.456 lb in. sec.^{2} The moment of inertia of any body may then be found conveniently by adding 3½ lb to its weight, determining the combined moment of inertia from Equation 3, and subtracting 0.456 from the combined moment of inertia to obtain the net moment of inertia of the body.

By G. A. Stolze
Research Department
Allis-Chalmers Manufacturing Co.
Milwaukee

Investment Castings

Requirements of design for proper casting

MOST designers are familiar, in a general way, with investment castings. However, it is apparent that many are not sufficiently acquainted with the process details and problems to design their parts so as to obtain best quality castings at lowest cost.

The decision to utilize investment castings is probably based on one or more of the following reasons:

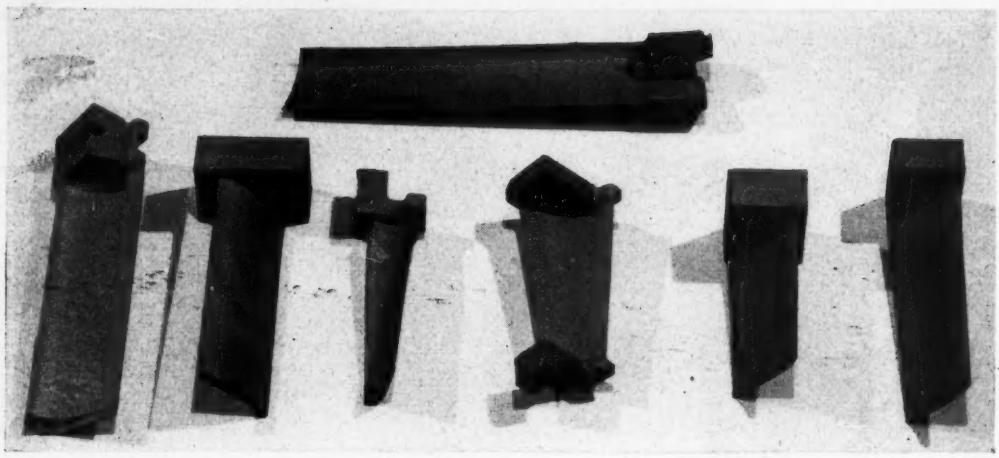
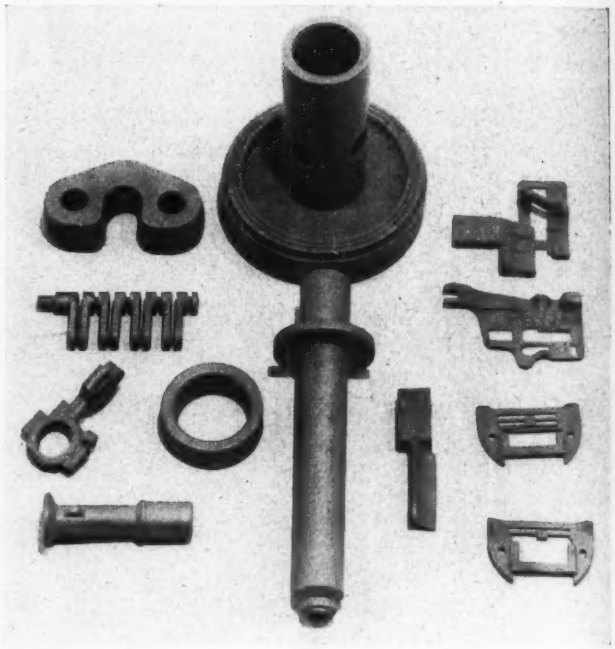


Fig. 1—Left—Assorted gas turbine and compressor blades cast from 3140 and 8620 steels

Fig. 2 — Below — Investment cast parts at left are clamp part, conveyor crank, connecting rod, ring, and vent valve part. In center are safety valve body and stem fitting. At right are sewing machine parts



The application may call for a material which cannot be readily machined, as for gas turbine blades such as those in *Fig.* 1; the elimination of machining may be an important cost reduction factor, as on the connecting rod in *Fig.* 2; there may be requirements of a smooth, pleasing appearance, combined with stainless material and low cost, as in food machine parts such as the conveyor crank in *Fig.* 2.

Usually parts designed for another method of manufacture can be cast as designed, though not always with best efficiency. In some cases, it may be too difficult or even impossible to cast the part without some redesign. Redesign is often easily accomplished through co-operation between the foundry's and the purchaser's engineers, but sometimes it is impractical to consider redesign, particularly where changing this one component of an assembly will require changes in other parts being made by other means. Obviously, it would be better if all castings could be originally designed with the problems and limitations of investment casting in mind, just as problems of chucking, tooling, etc., are considered when designing for machining.

The production of an investment casting with good physical properties is primarily a function of good gating design and careful adherence to sound foundry procedures. However, the designer can contribute by remembering that, while most investment-cast parts were formerly produced by forging or machining from bar stock, he is now designing the part for a process which is not greatly unlike sand casting.

TABLE I
Typical Physical Properties of Investment-Cast Steels

Part No.	Type of Steel	Ultimate Tensile Strength (psi)	Yield Point (psi)	Elongation in 1.4 inch (per cent)	Reduction of Area (per cent)	Hardness (Rockwell)	Condition of Specimen
1	3140	120,500	81,000	12	15	52A	As Cast
2	3130	88,000	52,000	13	24	45A	Annealed 1500 F
3	3140	220,500	215,500	2.2	5	38-42c	Water Quench 1525 F, Draw 825
4	8620	105,000	67,200	12.0	18.4	48A	Normalized 1700 F, 1 Hr Oil Quench 1650 F 1 Hr Draw 1150 F 4 Hr, Air Cool
5	410	104,500	83,000	20.0	59.0	20-22c	

The tensile test bars used in these tests were machined from ½-inch diameter precision cast bars machined to 0.357-inch diameter. The data on the 410 material is representative of the blading material used in production of steam-turbine blades. The modification of the manganese content was found to be necessary in order to eliminate microshrinkage.

Typical physical properties of steels used for casting axial compressor blades (1, 2, 3, 4) and steam turbine blades (5) are shown in TABLE I. These values were obtained from tests made with precision-cast test bars cast ½ inch in diameter and turned down to 0.357-inches. Chemical analyses for these steels are shown in TABLE II. In general, it may be said that the properties obtainable in properly produced castings are equal to those of the same alloys in wrought form. Tests made of investment-cast blades for turbines indicate that their properties are equal to those of forged blades, except for slightly lower ductility. In addition, they have the advantage, to the designer, of having the same properties in all directions, which forgings do not.

Generally investment castings have better properties than sand castings. In particular, since the molten metal is poured into hot molds, feed and cooling con-

ditions are better, making sounder, denser castings with no need for hot risers. The surface of precision castings is described as "velvety."

Many of the alloys utilized for investment castings are used in the as-cast condition. They include austenitic stainless steels, cast irons, brasses, and carbon steels. Nitriding steels have been cast successfully, but their as-cast hardness averages 400 Brinell. If they are to be machined after casting, some annealing treatment is usually necessary. It is helpful if designers specify a wide range of acceptable alloys for their parts, so that the one best suited to the problems of casting can be selected.

Gating Usually Is on Heaviest Section

Gating is of particular interest to the designer. He should be able to determine where gating is likely to be placed on his casting because close tolerances cannot be held on surfaces where gates or risers are attached.

For development work, to determine how to produce a particular casting free from dirt, porosity, and shrinkage, patterns are gated to form several probably desirable mold clusters. The resultant castings are carefully inspected by X-rays and other means and, if necessary, gating adjustments are made to eliminate defects. When favorable results are obtained from a test, the job is released for production.

If the casting is comparatively simple in design and is reasonably small (up to approximately 8 ounces), the gating may serve as an entrance point for the metal and a reservoir of molten metal to feed the casting as it solidifies. In this manner the gate serves as both gate and riser.

As a general rule, this type of gate is placed on the heaviest section of the casting, because this is the point where final solidification should occur. *Fig.* 3 shows several wax patterns with the gating attached, and also the final castings, cleaned and ready for shipment, produced from such patterns. These small parts will be attached, by means of the gate, to larger sprue structures, by means of which several individual parts are produced in one casting operation, as shown by the casting in *Fig.* 4.

In *Fig.* 1 is shown a casting with a heavy section isolated from the gate by very thin sections. Without special auxiliary feeders, this casting will either have a shrinkage depression in the center of the heavy section, or shrinkage porosity immediately adjacent to that section. The difficulty could be eliminated by increasing the size of the thin section or by adding a hole in the center of the isolated heavy section so as to reduce the mass of metal at that point. Use of an auxiliary gate to remove the shrinkage may not be desirable because it tends to distort the casting as it cools. Addition of this extra feeder also adds to wax pattern assembly as well as to casting and cleaning costs.

A casting having many sharp corners, undercuts, and unfilleted section changes tends to give trouble

TABLE II
Chemical Analyses

Part No.	C	Mn	Si	Cr	Ni	Mo
1	0.38	0.71	0.23	0.72	1.30	...
2	0.30	0.59	0.16	0.92	1.16	...
3	0.37	0.71	0.23	0.72	1.30	...
4	0.25	0.81	0.31	0.75	0.60	0.26
5	0.10	1.05	0.45	12.58	0.05	...

Fig. 3—Wax patterns and their castings at left are for a grater ring and conveyor crank. In center is a gated pattern for a rotor disk and gas turbine blade. Similar cast blade is shown below patterns. At right are patterns and castings for pressure foot and feed plate

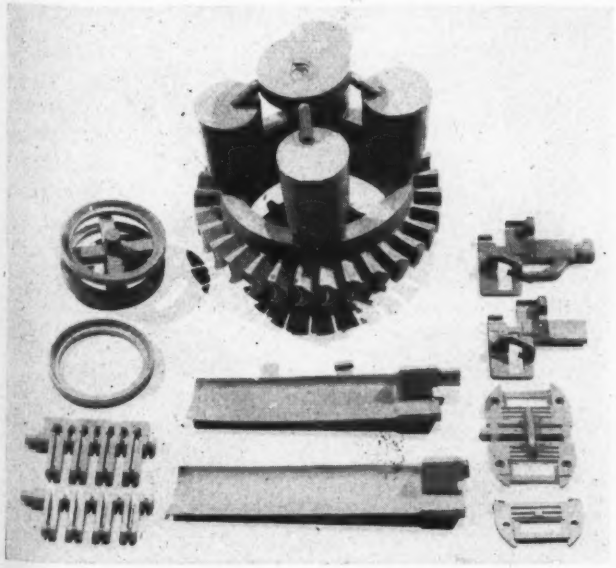
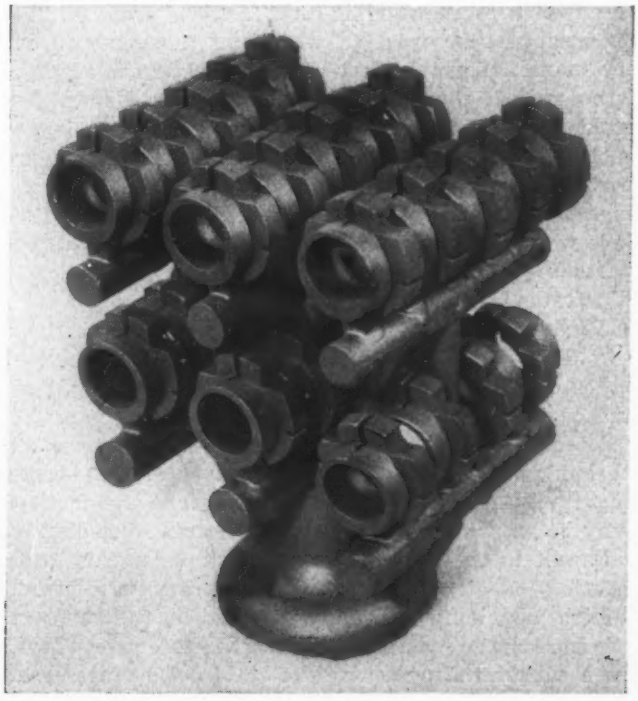


Fig. 4—Casting group formed from 27 individual wax patterns assembled on a wax sprue structure. After investing, dewaxing and casting as a unit the individual parts will be sawed free and the saw cut ground smooth.



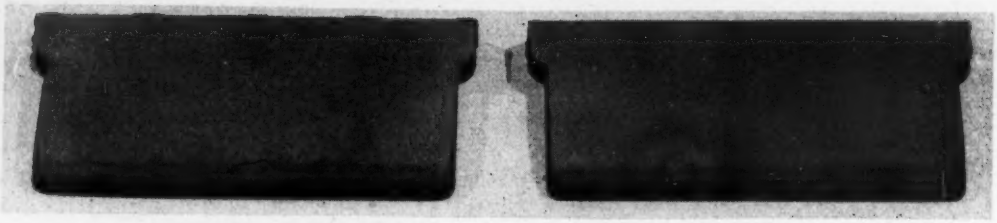


Fig. 5 — Unsuccessful casting of a large surface is shown at left, a successful cast surface is illustrated at right

due to dirt which is either washed from the sharp corners by the inrushing metal, or is flaked off during the preheating of the mold. Sharp corners and abrupt section changes separated by sharp corners tend to promote shrinkage as well as dirty castings. The sewing machine parts shown in *Fig.* 2 are good examples of castings which can cause such trouble. A designer may not consider abrupt section changes detrimental to a casting which will not be stressed appreciably, but scrap due to faulty castings may be reduced considerably by the elimination of sharp corners, especially internal corners, with consequent lowering of costs.

Flat Areas Involve Problems

Investing of molds containing patterns with large flat areas is often difficult, because the flat area must be so positioned in the mold that the investment can pack down against it. Castings which have been improperly invested have a surface defect called buckling, which may be accompanied by mold cracking and consequent finning. A smooth cast surface can usually be obtained by breaking up the straight surface through the addition of thin ribs placed normal to the flat area. These ribs would be ground off in the cleaning room. A defective and a successful casting with large flat areas are shown in *Fig.* 5.

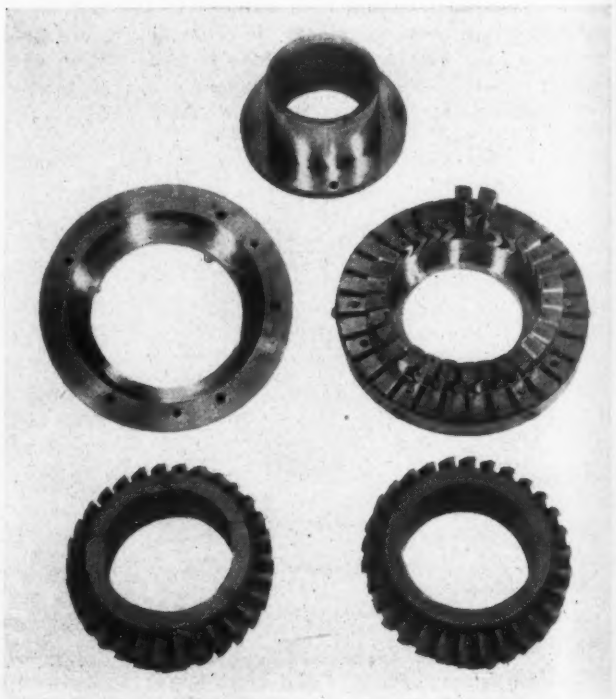
Production of a casting with long holes (L/D equals 10 plus) require special mold making procedures which may be excessively expensive. A long core which is required in this instance will usually need support in order to withstand the pressure or the uneven thermal effect of the metal as the casting is poured. If the core breaks, it produces dirt in the mold cavity and causes discontinuity in the inner casting surface. Although development work is under way to produce stronger investment materials, castings of this type could be more easily produced if the hole were eliminated or if the piece were made in two parts to be brazed or welded together later. *Fig.* 2 illustrates this type of casting.

Production of large castings is more intricate than any discussed so far. They must be fed by massive gates or risers approximately equal to the weight of the casting itself, and these gates or risers must be located so that the metal flow is equally distributed throughout the mold. If all the metal entered the casting cavity at one point, the depression in the casting may be as much as 0.06-inch in the area immediately adjacent to the gate. In order to minimize this local heating effect, the metal stream entry is divided. Finish machining is usually required on the surfaces of such large castings, since the gate areas will be a substantial percentage of the total surface area. A large gated pattern is shown in *Fig.* 3 and the die parts and casting in *Fig.* 6. On this particular job, stock for machining has been allowed on all surfaces except the blade contours.

In order to hold the out-of-round of ring castings to a minimum, it is necessary to use either three or four symmetrically located gates. Castings as shown in *Fig.* 2 may be made with a maximum out-of-round condition of 0.004-inch by the use of three-point symmetrical gating. If this casting were only gated at one point it would be about 0.017-inch out of round, with the small diameter being 90 degrees from the gate.

Blades such as those in *Fig.* 1 represent a real challenge to foundries. They are excellent examples of the freedom of choice of materials which investment casting permits. Accuracy in any single dimension is about the same as for other castings, but there is twist and lean to contend with. Blades approximately 3½ inch long have been made with the variation in twist being held to a tolerance of plus or minus ½-degree. Materials for high-temperature use, such as in gas-turbine blades, are often too hard or work-harden too rapidly to be readily machinable, but they may be investment cast with ease.

Fig. 6—In the foreground are a wax pattern and finished casting for a rotor. The die parts shown above have individual die segments which form the rotor blades and are retracted to permit removal of the pattern



MACHINE Editorial DESIGN

Road Machinery Points the Way

Whether the near future holds peace or war, the designer of machines can be credited with having placed us in a much stronger position than at any time in the country's history. Intensive engineering development, utilizing many of the lessons of World War II as a guide, have given research and design an impetus that cannot be discounted.

Of timely significance in this connection is the attention currently being paid to the planning and scope of national highway systems and the creation of new and dramatically outstanding road-building equipment. One could not view the recent exposition of highway construction machinery in Chicago without mixed feelings of pride and awe at the accomplishments of the engineers responsible for the development of the 5000 or more machines—amounting to around $25 million in value—that were on display.

Typical of the extent to which design has progressed in this field over the past few years is a huge bulldozer weighing 45 tons which can be operated virtually through finger-tip control. Embodied in the machine is an engine-driven generator for supplying current to the various motors for forward and reverse travel, raising and lowering the blade, etc. Pneumatic clutching and braking is utilized on this particular machine. The combination of electrical and pneumatic control provides almost unbelievable ease of operation for a machine of such tremendous size and capacity.

Readily discernible with regard to the general run of road machines featured at the exposition was the increased trend toward hydraulic actuation for straight-line or rotary motion. It might be said that the designers of practically every machine of the earth-moving type have now adopted this method of operation and control.

With highway vehicle registration throughout the country totaling close to 40 million for the year, and an anticipated increase to around 60 million within the next four or five years, the need for the highly developed construction machinery now available is plainly evident. The designers have done a commendable job in providing equipment for the construction of first-class peacetime highways. Their machines also would be invaluable, probably even more so than in the last war, in the "overnight" building of air fields and for other military purposes if the necessity should arise.

L. E. Jermy

DESIGNS OF THE MONTH

Hydraulic Valve Lifters in Motorcycle Engine

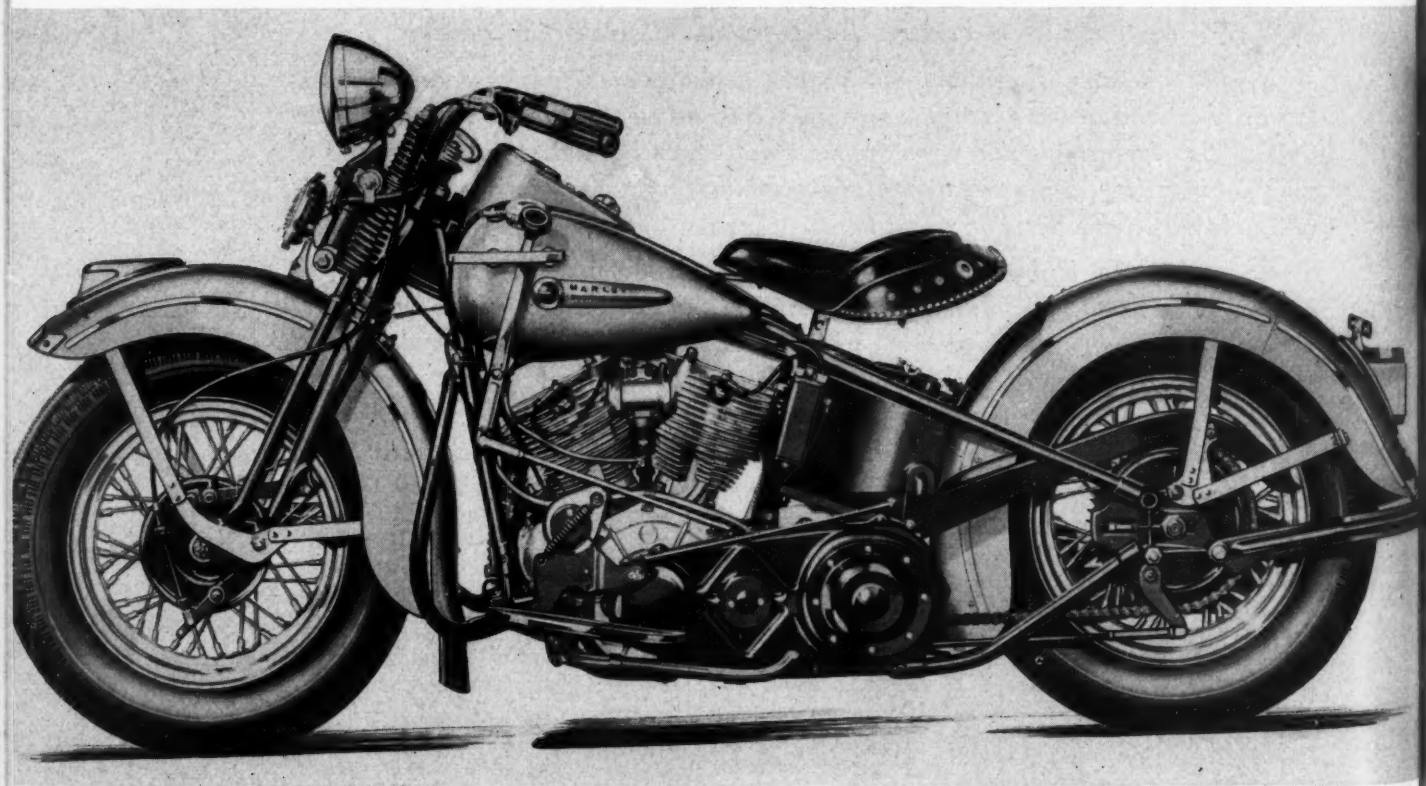
TO MAINTAIN zero clearance between rocker arms and valves and thus insure quiet operation and accurate engine timing, hydraulic valve lifters are used in the engine of the 1948 Harley-Davidson motorcycle, below. As the engine cutaway, bottom, next page*, and the cross section drawing, extreme right, show, the lifter consists essentially of a plunger operating in a cylinder, there being a controlled leakage rate between these two parts.

Top end of the plunger, spherical in shape, contacts the rocker arm, while the lower portion of the plunger contains a check ball which controls oil flow into the unit. Travel of the ball is limited by the retainer which is held in position by a spring. At installation, the clearance space below the plunger is adjusted to approximately 1/16-inch. This insures that room will be available for oil and compensates for expansion and contraction in the engine valve assembly. Adjustment of this mechanical clearance is made by means of the screw and lock nut in the tappet.

A snap ring located at the top of the cylinder serves to hold the assembly together during handling of the unit and also limits travel of the plunger. If this limited travel were not provided and a valve spring were to break, the plunger would "follow up" immediately and the valve might be pushed into the cylinder head, causing considerable damage.

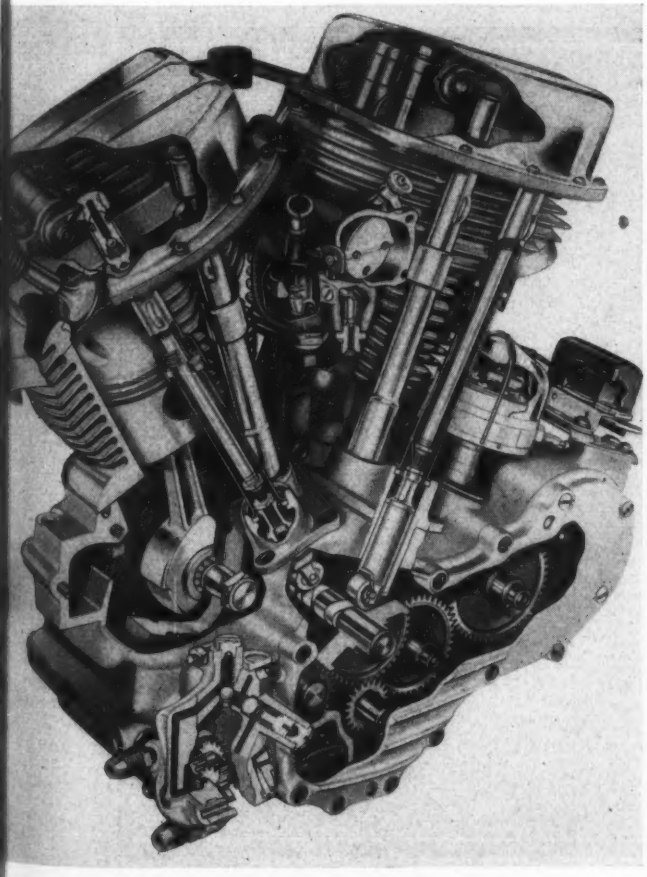
In operation, the spring presses the plunger

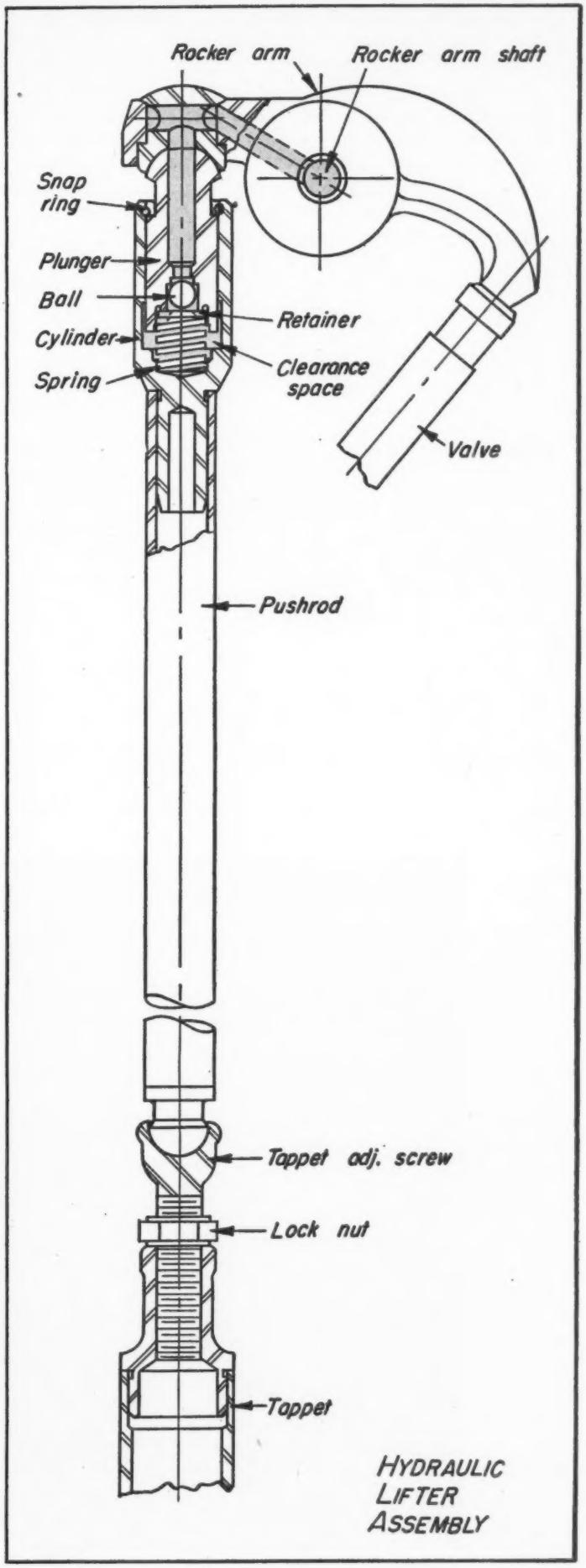
* Cutaway view of engine is also shown on front cover of this issue of MACHINE DESIGN.



top against the spherical cup of the rocker arm, the other end of the rocker arm being in contact with the engine valve. The clearance space below the plunger is filled with oil from the engine lubricating system, being fed from the center of the rocker arm shaft through a drilled hole in the rocker arm and down through the center of the plunger. When the check ball is forced onto its seat by upward movement of the oil column, the oil in the chamber, being substantially incompressible, lifts the entire valve mechanism.

During the valve opening cycle a slight but accurately predetermined amount of oil is permitted to escape between the cylinder wall and the plunger. This slight amount of leakage allows for expansion and contraction in the engine valve train, thus assuring that the valve will always seat. Movement of the plunger with relation to the cylinder probably will be no greater than 0.001-inch for each lift-cycle of the valve. When the tappet reaches the base circle of the cam after the valve has seated, the load is released from the hydraulic unit, the ball leaves its seat, and the clear-





HYDRAULIC LIFTER ASSEMBLY

ance chamber is again replenished with an amount of oil equal to that which has escaped between plunger and cylinder during the lift cycle.

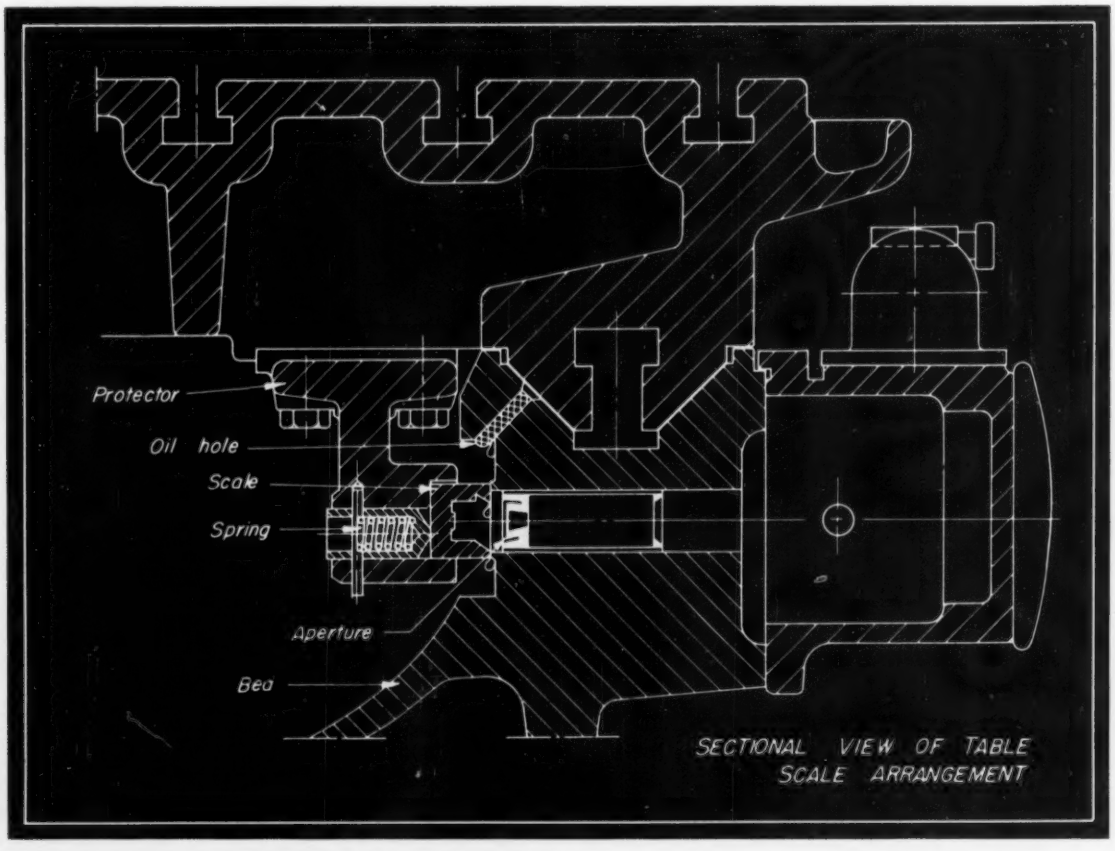
Heads of the engine are aluminum, finned to provide additional cooling. Ampco metal inserts are incorporated for valve seats, and five steel mounting-screw sockets and a steel spark-plug insert are cast into each head. Engine rocker-arm bearings are new in design, the lower halves being cast iron and the upper halves bronze. A single cover encases the rocker arm mechanism over each head. The cover is felt lined at the top to reduce noise and chromium plated to enhance appearance. Entire rocker arm mechanism operates in an oil mist which assists materially in cooling the aluminum heads. Tappet rollers are needle-bearing mounted. Exhaust pipes fit on the outside of the exhaust ports and are held securely by stainless steel clamps which prevent exhaust gas leakage. All lighting and ignition wires lead into and through a terminal box situated below the saddle and behind the spark coil. Terminals on all wiring are crimped on instead of soldered and are insulated with vinylite plastic tubing. Manufacturer of valve lifter: Eaton Manufacturing Co., Detroit 13. Manufacturer of motorcycle: Harley-Davidson Motor Co., Milwaukee 1.

Optical Measuring System Built into Jig Borer

EXTREME accuracy in drilling, boring and milling is achieved through outstanding design and construction features in the "SIP Hydroptic" jig borer shown on the opposite page. This machine does not depend on lead-screw accuracy, nor dial settings for precise positioning of its work table and spindle saddle. Instead, it employs an optical measuring system using built-in high-precision scales and micrometer microscopes.

How the table scale has been built in is shown in the cross section drawing, below. The scale is surrounded by a protector and pressed against an inside face of the bed by a series of small springs. Graduated surface of the scale is at the base of its U-shaped longitudinal groove. Both extremities of the scale are provided with closing plates containing oil-soaked felt packing which insures lubrication of the scale surface contacting the bed. This oil film produces a dust-proof joint. Oil is constantly renewed by way of wick-filled oil holes which communicate with the V-ways of the bed. The beveled surface along the inside edge of the scale base prevents oil from flooding the graduated surface of the scale by directing it toward the joint face. Observation of the scale is through the aperture which is air-sealed by a lens.

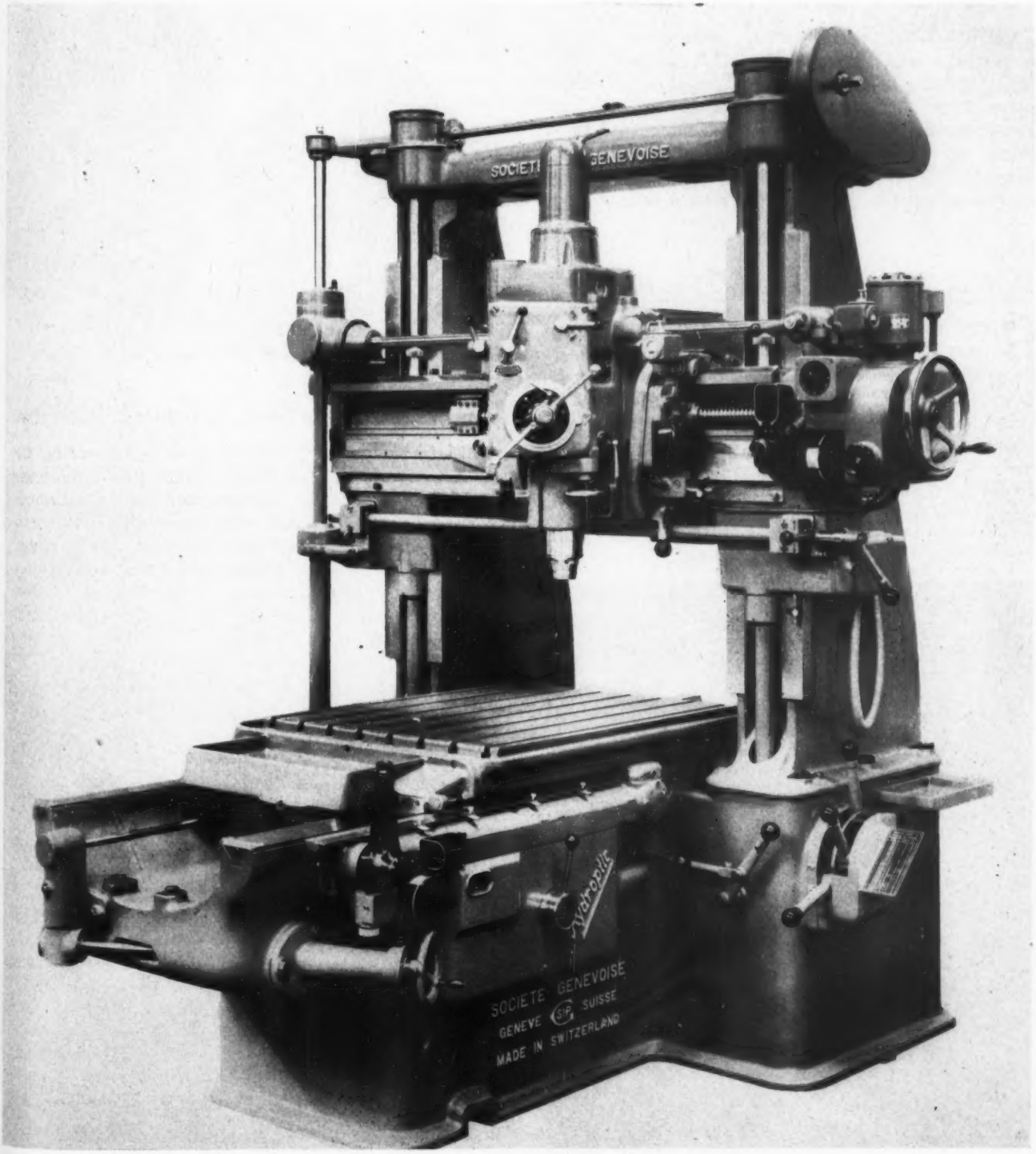
In operation, the work table is moved by a variable-speed hydraulic drive, but its positioning is established first by reference to a divided drum dial, and finally by sighting through the microscope and matching a



dotted line of the microscope reticle with the desired line on the built-in scale. This procedure applies also to positioning of the spindle saddle.

Inaccuracies due to temperature changes are minimized by matching the coefficients of expansion of the scales and the machine frame members. The scales are 58 per cent nickel steel and the frames are cast iron. Vertical ways of the machine are scraped to curves such that when the weight of the spindle saddle unit is applied, the ways deflect to a straight line. Frame castings are aged six months, then machined and scraped three times between normalizing treatments. Thus all internal stresses are removed.

Spindle of the jig borer runs in three special precision bearings and axial play is automatically compensated. The spindle quill, of nitrided steel, is carefully lapped in the spindle head, the totally-enclosed construction of which prevents ingress of dirt. Six automatic rates of power feed are available in either direction in conjunction with eighteen spindle speeds. Manufacturer: Societe Genevoise, Geneva, Switzerland.

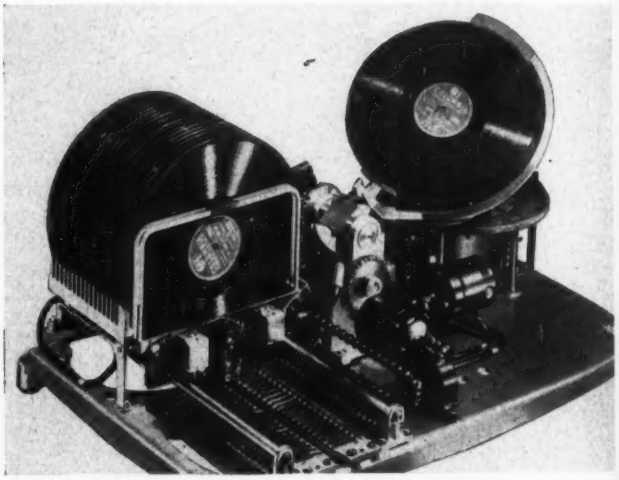


Applications

of engineering parts, materials and processes

Roller Chain Actuates Record Selector

INTERESTING reciprocating motion is accomplished compactly on the new AMI record changer, right, by the application of short-pitch Diamond roller chain. The ½-inch pitch chain used has one special extending pin which engages the record rack. Driven by a gearmotor, the chain causes the pin to execute a reciprocating motion which accurately and positively positions the rack for record selection.

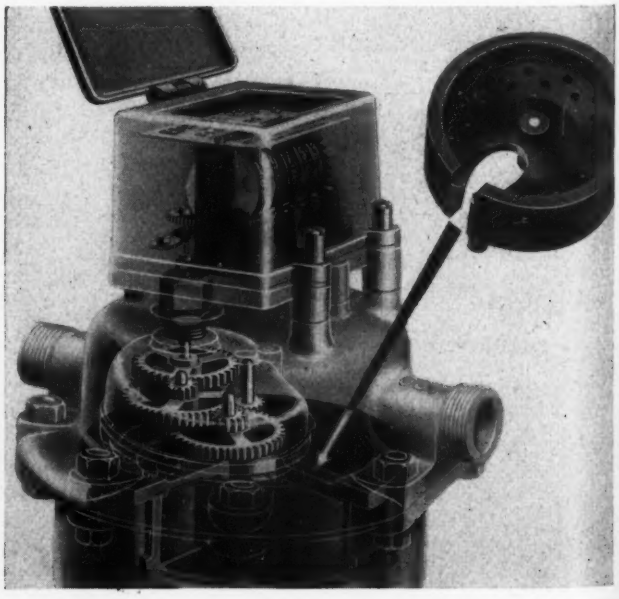


Plastic Develops Static Charge

HIGH dielectric properties of Kriston resin are used in an unusual manner in the Condenser-Meter seen below. Used to measure the intensity of X-ray beams, the meter requires the generation of large static charges as a means of measuring ionization. This is accomplished by manually spinning a brush in contact with the plastic plate. Resultant charge is dependable, 400-volts being generated by each spin of the brush.

Carbon-Graphite Piston Measures Fluid Flow

FLUID meter, below, for accurately measuring the flow of hot oil and other liquids, has a metering piston of Morganite carbon-graphite. Continuous flow of fluid causes the piston to oscillate, this motion being transmitted through gears to register. The low coefficient of expansion as well as the non-warping and self-lubricating properties of carbon-graphite resulted in its selection for this close-fitting part operating in hot solvent.

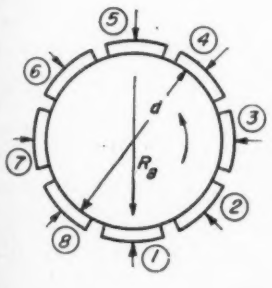


Load Capacity and Friction of Pivoted-Shoe Bearings

By H. A. S. Howarth
Bearing Engineer
Philadelphia, Pa.

Part II—Journal Bearings

PIVOTED shoe journal bearings may have any desired number and proportion of shoes. However, experience has shown that for most purposes best results are attained with a "square" shoe subtending an angle of 38¼ degrees. A shoe of these proportions has length and width each equal to one-third of the shaft diameter. Eight such shoes may be fitted around the circumference of the shaft *Fig.* 3 although, for load in only one direction, fewer shoes are sufficient, *Figs.* 4 and 5.



$$h_1 = (1 - c)\eta$$
$$h_2 = h_8 = (1 - 0.7071c)\eta$$
$$h_3 = h_7 = \eta$$
$$h_4 = h_6 = (1 + 0.7071c)\eta$$
$$h_5 = (1 + c)\eta$$

$$R = A_s\,[p_{01} - p_{05} + 0.7071\,(p_{02} + p_{08} - p_{04} - p_{06})]$$

Fig. 3—Eight-shoe journal bearing with formulas for average film thickness at each shoe, and load capacity

TABLE III presents, for selected bearing sizes and speeds, the load and friction characteristics of 8-shoe (*Fig.* 3) and 5-shoe (*Fig.* 4) bearings. For each bearing size the first two lines give the average film pressure, p_{01}, and minimum film thickness, h_{01}, respectively for the shoe directly under the load (shoe No. 1). The next line gives the speed of the journal, N_d, in revolutions per minute. The next line gives the radial clearance, η. The remaining lines give the total load R and total friction horsepower H for bearings having 8 and 5 shoes respectively, the subscripts 8 and 5 being used with R and H for identification.

Inasmuch as the side shoes, Nos. 3 and 7, contribute nothing to the load capacity, a bearing with 3 shoes, *Fig.* 5, will have the same capacity as the 5-shoe bearing, and therefore $R_3 = R_5$. Friction horsepower, H_3, is less, however.

FILM THICKNESS: The table is based on the creation of a film shape capable of carrying the greatest load for a given minimum film thickness, h_0. Under this condition the mean film thickness is $h = 1.594h_0$. For 38¼-degree journal shoes the same minimum film thickness has been chosen as for the 38¼-degree thrust shoes covered in last month's data sheet. Hence the first three lines for each bearing size in TABLE III are identical with those in TABLE II.

With the journal center displaced an amount $c\eta$, where c is the eccentricity factor and η is the radial clearance, the mean film thickness for the other shoes of an 8-shoe bearing are as given in the equations on *Fig.* 3. Clearance, η, is established by equating the value of h_1 given on *Fig.* 3 and the relation $h_1 = 1.594h_{01}$, from which

$$\eta = \frac{1.594h_{01}}{1 - c}$$

In the tables the eccentricity factor has been taken

TABLE III. Load Capacity and Friction Horsepower of 38¼-degree Pivoted Shoe Journal Bearings

d (in)	A_s (sq in)	V_d (ft per sec)	5	10	20	40	60	80	100	120	140
4½	2¼	p_{o1} (psi)	180	214	255	303	336	361	382	399	414
		h_{o1} (in.)	.000346	.000448	.000582	.000754	.000878	.000980	.00106	.00114	.00121
		N_d (rpm)	254	509	1018	2036	3053	4071	5089	6107	7124
		η (in.)	.001102	.001428	.001855	.002404	.002800	.003125	.003380	.003635	.003860
		R_8 (lb)	626	744	887	1053	1167	1255	1328	1386	1440
		H_8 (hp)	.0380	.1180	.3630	1.120	2.166	3.450	4.960	6.670	8.530
		R_5 (lo)	749	891	1061	1261	1397	1500	1590	1660	1720
		H_5 (hp)	.0292	.0907	.2790	.860	1.665	2.650	3.810	5.120	6.550
9	9	p_{o1} (psi)	214	255	303	361	399	429	453	475	493
		h_{o1} (in.)	.000448	.000582	.000754	.000980	.00114	.00126	.00138	.00147	.00157
		N_d (rpm)	127	254	509	1018	1526	2036	2544	3053	3562
		η (in.)	.001428	.001855	.002404	.003125	.003635	.004020	.004400	.004685	.005010
		R_8 (lb)	2980	3550	4220	5020	5550	5970	6300	6610	6860
		H_8 (hp)	0.1180	0.3630	1.120	3.450	6.670	10.68	15.33	20.64	26.40
		R_5 (lb)	3560	4250	5050	6020	6650	7150	7550	7910	8220
		H_5 (hp)	0.0907	0.2790	0.860	2.650	5.120	8.20	11.80	15.90	20.30
13½	20¼	p_{o1} (psi)	236	281	336	399	442	475	500	525	545
		h_{o1} (in.)	.000522	.000677	.000878	.00114	.00133	.00147	.00161	.00172	.00182
		N_d (rpm)	85	170	339	679	1018	1357	1696	2036	2375
		η (in.)	.001664	.002160	.002800	.003635	.004240	.004685	.005135	.005485	.005810
		R_8 (lb)	7390	8800	10,520	12,500	13,840	14,870	15,650	16,440	17,060
		H_8 (hp)	0.227	0.701	2.170	6.670	12.85	20.64	29.60	39.70	51.10
		R_5 (lb)	8840	10,510	12,580	14,940	16,540	17,770	18,730	19,650	20,400
		H_5 (hp)	0.174	0.539	1.670	5.120	9.87	15.90	22.75	30.50	39.30
18	36	p_{o1} (psi)	255	303	361	428	474	508	538	565	592
		h_{o1} (in.)	.000582	.000754	.000980	.00126	.00147	.00164	.00179	.00192	.00203
		N_d (rpm)	64	127	254	509	763	1018	1272	1527	1781
		η (in.)	.001855	.002404	.003125	.004020	.004685	.005230	.005715	.006125	.006475
		R_8 (lb)	14,200	16,850	20,100	23,800	26,400	28,300	29,950	31,450	32,950
		H_8 (hp)	0.363	1.120	3.460	10.68	20.64	32.90	47.25	63.30	81.40
		R_5 (lb)	16,980	20,200	24,060	28,500	31,600	33,860	35,850	37,650	39,450
		H_5 (hp)	0.279	0.860	2.660	8.20	15.90	25.30	36.30	48.70	62.50
22½	56¼	p_{o1} (psi)	269	321	382	453	500	539	571	597	619
		h_{o1} (in.)	.000632	.000820	.00106	.00138	.00161	.00179	.00195	.00208	.00220
		N_d (rpm)	51	102	204	407	611	814	1018	1221	1425
		η (in.)	.002015	.002615	.003380	.004400	.005135	.005715	.006220	.006630	.007020
		R_8 (lb)	23,400	27,900	33,200	39,400	43,500	46,850	49,650	51,900	53,800
		H_8 (hp)	0.522	1.610	4.960	15.33	29.60	47.25	67.8	91.5	117.4
		R_5 (lb)	28,000	33,400	39,750	47,200	52,000	56,100	59,400	62,150	64,400
		H_5 (hp)	0.401	1.240	3.810	11.80	22.75	36.30	52.1	70.3	90.2
27	81	p_{o1} (psi)	281	336	399	474	525	565	597	625	649
		h_{o1} (in.)	.000678	.000878	.00114	.00147	.00172	.00192	.00208	.00223	.00237
		N_d (rpm)	42.3	85	170	339	509	679	848	1018	1187
		η (in.)	.002161	.002800	.003635	.004685	.005485	.006125	.006630	.007115	.007560
		R_8 (lb)	35,200	42,100	50,000	59,400	65,750	70,750	74,750	78,250	81,300
		H_8 (hp)	0.701	2.164	6.670	20.64	39.70	63.30	91.40	122.5	157.4
		R_5 (lb)	42,100	50,300	59,800	71,000	78,700	84,700	89,500	93,700	97,200
		H_5 (hp)	0.539	1.664	5.120	15.90	30.50	48.70	70.20	94.2	120.6
31½	110¼	p_{o1} (psi)	293	348	414	493	545	589	619	650	673
		h_{o1} (in.)	.000718	.000930	.00121	.00157	.00182	.00204	.00220	.00237	.00250
		N_d (rpm)	36.4	73	145	291	436	582	727	872	1018
		η (in.)	.002290	.002966	.003860	.005010	.005810	.006510	.007020	.007560	.007975
		R_8 (lb)	49,900	59,300	70,600	84,000	92,900	100,300	105,400	110,600	114,600
		H_8 (hp)	0.900	2.780	8.570	26.40	51.10	81.40	117.40	157.4	203.0
		R_5 (lb)	59,700	71,000	84,400	100,400	111,000	120,000	126,000	132,400	137,000
		H_5 (hp)	0.692	2.14	6.580	20.30	39.30	62.50	90.20	120.6	156.0

R_8 and H_8 denote total radial load capacity and total friction horsepower, respectively, for an 8-shoe bearing. R_5 and H_5 denote corresponding values for 5-shoe bearing (Fig. 4).

Table is based on $\mu = 3.4 \times 10^{-6}$ lb-sec per sq in. (Reyns) equivalent to 0.2345 poise or 23. 45 centipoise. When loading higher than the tabular value of p_{o1} or H is required, increase the viscosity in the ratio of pressure in order to maintain film thickness. Horsepower loss will increase in the same ratio.

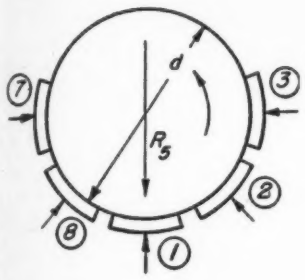


Fig. 4—Above, left—Five-shoe bearing, which is Fig. 3 after removal of top three shoes

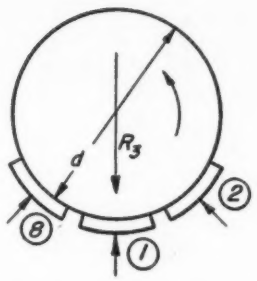


Fig. 5—Above, right—Three-shoe bearing, which has same load capacity as Fig. 4 but less friction

equal to 0.5, hence $\eta = 3.188h_{01}$.

LOAD CAPACITY: The relation between minimum film thickness and average film pressure is given in Equation 1 of last month's data sheet:

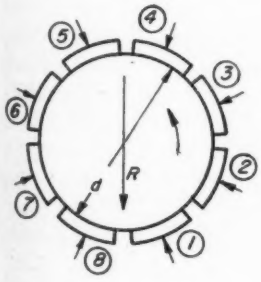
$$h_0^3 = \frac{1.92\mu v l L_1}{p_0}$$

Using the side leakage factor for load, $L_1 = 0.437$ for a square shoe, replacing l by its value $d/3$, and using the relation $h = 1.594h_0$, the equation becomes:

$$p_0 h^2 = 0.7105\ \mu v d \qquad (4)$$

Using the values of h in *Fig.* 3, the average film pressure on each shoe can be calculated from Equation 4. To determine the total load sustained by the bearing, the components of the load on each shoe in the direction of the load must be determined. The result is a summation for R which is given in *Fig.* 3. If any shoes are omitted, the corresponding pressure values would become zero in the equation for R.

Fig. 6—Eight-shoe journal bearing with resultant load passing between two shoes. Formulas gave average film thickness for each shoe and total load capacity



$$h_1 = h_8 = (1 - 0.9239c)\eta$$
$$h_2 = h_7 = (1 - 0.3827c)\eta$$
$$h_3 = h_6 = (1 + 0.3827c)\eta$$
$$h_4 = h_5 = (1 + 0.9239c)\eta$$

$$R = A_s\,[0.9239\ (p_{01} + p_{05} - p_{04} - p_{08}) + 0.3827\ (p_{02} + p_{07} - p_{03} - p_{06})]$$

ENGINEERING DATA SHEET

When the shoes are arranged in such a manner that the load is directed between two shoes, the equations for average film thickness become as shown on *Fig.* 6. The corresponding total load sustained by the bearing is given by the equation for R also shown on the figure. Application of the foregoing equations shows that the load capacity is substantially the same for the bearings of *Fig.* 3 and *Fig.* 6, for the same radial clearance and eccentricity.

FRICTION HORSEPOWER: Horsepower per shoe lost in friction is given by Equation 3 in last month's data sheet:

$$H_s = 1.646\ \mu \times 10^{-2} \times F_1 \frac{A_s v^2}{h_0}$$

Substituting the side leakage factor for friction, $F_1 = 0.908$ for a square shoe, and $h = 1.594h_0$, the equation becomes:

$$H_s h = 0.02382\ \mu\ A_s v^2 \qquad (5)$$

Knowing the value of h for each shoe from *Fig.* 3 or *Fig.* 6, the loss at each can be calculated from Equation 5 and the total friction horsepower determined by summation.

EXAMPLE: To illustrate the calculations on which the table is based, the figures for a 13½-inch diameter bearing at 40 ft per sec velocity will be checked. As pointed out previously, the figures $p_{01} = 399$, $h_{01} = 0.00114$, and $N_d = 679$ are the same as in TABLE II of last month's data sheet. Clearance is $\eta = 3.188h_{01} = 3.188 \times 0.00114 = 0.003635$. Using equations in *Fig.* 3, $h_1 = (1-0.5)\ (0.003635) = 0.001817$; $h_2 = h_8 = (1-0.3535)\ (0.003635) = 0.00235$; $h_3 = h_7 = 0.003635$; $h_4 = h_6 = (1+0.3535)\ (0.003635) = 0.00492$; $h_5 = (1+0.5)\ (0.003635) = 0.00545$.

From Equation 4, $p_0 h^2 = 0.7105\ \mu v d = 0.7105 \times 3.4 \times 10^6 \times 40 \times 13\frac{1}{2} = 1.305 \times 10^{-3}$. Substituting the foregoing values of h in this equation: $p_{02} = p_{08} = 1.305 \times 10^{-3}/0.00235^2 = 237$ psi; $p_{04} = p_{06} = 1.305 \times 10^{-3}/0.00492^2 = 54$ psi; $p_{05} = 1.305 \times 10^{-2}/0.00545^2 = 44$ psi.

Substituting these values in the equation for R on *Fig.* 3, $R_8 = 20.25\ [399 - 44 + 0.7071\ (237 + 237 - 54 - 54)] = 12{,}500$ lb.

From Equation 5, $H_s h = 0.02382 \times 3.4 \times 10^{-6} \times 20.25 \times 40^2 = 2.625 \times 10^{-3}$. Substituting the values of h previously found, $H_{s1} = 2.625 \times 10^{-3}/0.001817 = 1.45$ hp; $H_{s2} = H_{s8} = 1.12$ hp; $H_{s3} = H_{s7} = 0.72$ hp; $H_{s4} = H_{s6} = 0.53$ hp; $H_{s5} = 0.48$. Summing, $H_s = (1.45 + 2 \times 1.12 + 2 \times 0.72 + 2 \times 0.53 + 0.48) = 6.67$ hp.

Assets to a Bookcase

Steel Castings

By Eric N. Simons; published by the Chemical Publishing Co., Inc., Brooklyn, N. Y.; 216 pages, 4½ by 7¼ inches, clothbound; available through MACHINE DESIGN, *$5.00 postpaid.*

Written to satisfy the need for an overall compilation on the subject of steel castings, this book does its job well. While it is not directed explicitly to the designer, being far broader in coverage than his usual needs demand, the volume should be an excellent reference work for the engineer who is continually engaged in casting design.

Virtually all aspects of steel foundry practice have been covered in the book. Starting with the raw materials used, the reader is acquainted with melting processes, pattern-making practice, the various mold making and casting techniques, and heat treating and machining practice. The last two sections of the book, dealing with steel alloys and unusual castings, should be of particular interest to the engineer; they are the largest single portions of the volume and represent a careful compilation of data on aspects of primary importance in design. Included in this portion of the book are detailed descriptions of the steels that may be selected and the applications to which they may be applied. One large table, for example, divides steels into eight categories of carbon and alloy types and for each group outlines recommended uses. The text further elaborates on these data.

□ □ □

Mechanical Vibrations

By J. P. Den Hartog, professor of mechanical engineering, Massachusetts Institute of Technology; published by McGraw-Hill Book Co. Inc., New York; 478 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, *$6.00 postpaid.*

This is the third edition of the well-known treatise on vibration first published in 1934. In the interim, the author has profited by his experience in consulting work as well as with the Bureau of Ships during the war to modify the volume and provide a number of additions. Basic changes are an increase in the number of problems given and the treatment of a number of new subjects. These new subjects include airplane wing flutter, helicopter ground vibration, torsional vibration dampers, singing ship propellers, and electrical instruments.

The book remains a superb reference in the field of vibration, covering presently known problems well. The eight chapters treat the subjects of vibration kinematics; one, two and many degrees of freedom; rotating machinery; self-excited vibrations; and systems with variable characteristics. The volume is replete with illustrations and careful developments of the mathematical statements.

□ □ □

Engineering Organization and Methods

By James E. Thompson, consulting industrial engineer; published by McGraw-Hill Book Co. Inc., New York; 337 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, *$4.00 postpaid.*

This book is designed to assist the technical administrator organize, operate and control a modern engineering department according to proved techniques. It provides a basic organization plan and supplies detailed procedures for a number of specific functions, such as routing, together with the forms required and examples of the proper use of each form. Contents includes chapters on organization, operation, planning, standards, drawing control, and the fundamentals of engineering management. The appendix contains two sections covering cost analysis and time-charge procedure. In these sections typical examples are worked out in detail.

Hardenability of Alloy Steels

Over sixty steels which may be specified by the hardenability band system are described in this latest presentation on alloy steel selection entitled, "Hardenability of Alloy Steels." For those who are not familiar with the hardenability method of specifying ferrous alloys, this volume will be of particular value for it also contains Boegehold's outstanding paper, "Selection of Automotive Steel on the Basis of Hardenability." This paper explains the hardenability theory, describes how to select steels by hardenability and reveals the advantages of the H-band as a buying index. Four sections are included in the volume in all, the third section describing the SAE method of determining hardenability and the fourth section presenting six tables on conversion of steel hardness numbers. Paperbound, the book measures 6 by 9 inches and contains 146 pages. It is priced at $1.00 to SAE members and $2.00 to others and is available through the Society of Automotive Engineers, 29 W. 39th St., New York 18.

MEN ... of machines

ROY J. SANDSTROM has been appointed executive chief engineer of Bell Aircraft Corp., Buffalo, following the resignation of ROBERT M. STANLEY as vice president in charge of engineering. Mr. Sandstrom has been associated with Bell's engineering department since 1938, his first assignments dealing with stress analysis. He later was appointed project engineer and first preliminary design engineer. At the time of his recent advancement, Mr. Sandstrom was chief of technical services and was in charge of all the company's military engineering work. He is an aeronautical engineering graduate of the University of Michigan, and prior to joining Bell Aircraft, served for two years with the Airplane Div., Curtiss-Wright Corp., and with Lockheed Aircraft.

Roy J. Sandstrom

O. E. EGGEN, director of engineering of the Oliver Corp., Chicago, recently was elected a vice president of the corporation. Mr. Eggen has been associated with the organization since 1928, joining the Charles City plant as chief engineer and in 1942 becoming plant manager. During this period Mr. Eggen played an important part in the development of the modern farm tractor. In 1944 he was transferred to Chicago and was appointed director of engineering for all Oliver products. In addition, during 1946 and 1947 Mr. Eggen was Cleveland plant manager.

EARL H. LENZ recently has been appointed director of engineering for the Twin Coach Co., Kent, O., and will co-ordinate all engineering activities of the organization. Mr. Lenz joined the company in 1946 as production engineer. His previous experience includes fifteen years' engineering responsibility with E. I. DuPont de Nemours Co., and prior to joining Twin Coach, Mr. Lenz had been associated for three years with Curtiss-Wright Corp.

EVERETT S. LEE was elected president of the American Institute of Electrical Engineers at its annual meeting held recently in Mexico City. Mr. Lee

O. E. Eggen

Earl H. Lenz

Everett S. Lee

originally joined the institute in 1911 as a student member while attending the University of Illinois. During the past thirty-seven years he has been extremely active in the service of the organization not only in the preparation and presentation of numerous papers, but also serving on many committees both as a member and chairman. In addition, Mr. Lee was a director of the AIEE from 1933 to 1936 and was vice president of district one in 1940-41. An electrical engineering graduate of the University of Illinois, 1913, Mr. Lee also received a master's degree in electrical engineering from Union College in 1915. He has been associated in various engineering capacities with the General Electric Co. since his release from the army after World War I and has been an engineer in its general engineering and consulting laboratory since 1945. Mr. Lee is widely known for his work in the field of measurements in the electrical industry.

♦

PETER F. ROSSMAN has been elected president of Symington-Gould Corp., Depew, N. Y., succeeding J. A. SAUER, retired. Mr. Rossman served during the war as chief of development research for Curtiss-Wright Corp., Buffalo. He has also held executive positions in connection with design with Packard Motor Co.

♦

D. J. CUMMINS, associated with Cummins Engine Co. Inc., Columbus, Ind., since 1919, recently was elected vice president in charge of engineering. Mr. Cummins worked on early Cummins' experimental projects and has been manager of engineering since July, 1947. In his new capacity Mr. Cummins will be in charge of research, production engineering and quality control.

♦

R. M. DILWORTH, chief engineer since 1926 of the Electro-Motive Div., General Motors Corp. at La-Grange, Ill., has been named engineering assistant to vice president. Mr. Dilworth is in charge of the recently expanded engineering activities of that organization. E. W. KETTERING, formerly assistant chief engineer is now chief engineer and L. F. CAMPBELL, formerly chief production engineer has been appointed executive engineer.

♦

GEN. WILLIAM H. HARRISON has been elected president of the International Telephone & Telegraph Corp. He will leave his position as vice president in charge of operations and engineering of the American Telephone & Telegraph Co. Sept. 1.

♦

DR. HARRY C. ENGEL has been appointed to succeed the late W. W. Troxell as chief of the engineering laboratories of the Glenn L. Martin Co. Dr. Engel first became associated with the Martin company in 1940 as manager of a fellowship at Mellon Institute, Pittsburgh, which was engaged in research on structural plastics. This project prepared him well for his work in developing Martin's honeycomb construction material. In 1942 Dr. Engel became a design engineer at Baltimore where he continued work on sandwich constructions. Since 1945 he has been connected with the company's engineering laboratory as head of the nonmetal unit.

♦

WILLIAM H. TAYLOR has been appointed director of engineering for Tinnerman Products Inc., Cleveland.

♦

The engineering mechanics department of Midwest Research Institute announces the following recent appointments: MALCOLM R. EASTERDAY, HERBERT ARENSON, WALLACE M. YOCUM, and LAWRENCE A. PLATT.

♦

GEORGE SQUIBB has been named chief engineer of the Detroit Broach Co., replacing LEON CAPLEN who has resigned after thirteen years in that position. Mr. Caplen continues his association with the company as consulting engineer.

♦

JOHN K. MCNEELY, actively engaged in aviation engineering since 1931, has joined Jack & Heintz Precision Industries Inc., Cleveland, as special aviation project engineer. In addition, WALTER KOELLIKER has been named an engineer for the special aviation projects section. During the war Mr. Koelliker was commanding officer of the Army's detachment at Sperry Gyroscope Co.

♦

ROBERT F. NELSON has been elected a director and vice president in charge of all engineering and manufacturing operations for American Type Founders Inc., Elizabeth, N. J. Mr. Nelson had previously been associated with R. G. LeTourneau Inc.

♦

LOUIS D. MARTIN, gear engineer with Eastman Kodak Co., Rochester, N. Y., was honored at the recent annual meeting of the American Gear Manufacturers Association. For his "immeasurable contributions to the gearing industry's knowledge and literature, particularly in the fine pitch gearing field," Mr. Martin was named recipient of the association's Connell award which is presented annually. Mr. Martin's entire career has been spent in the gearing industry. For the past twenty-two years he has been associated with Eastman Kodak and is currently in charge of all its gear engineering and development.

♦

E. J. G. PHILLIPS, director of engineering for Richards Wilcox Mfg. Co., Aurora, Ill., has been elected president of the Monorail Manufacturers Association.

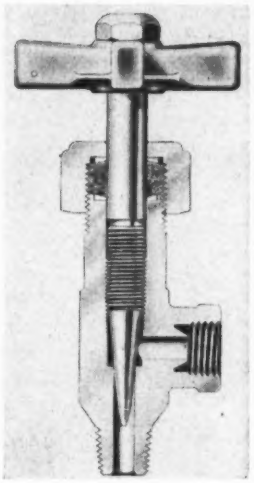
♦

JOHN W. OVERBEKE recently has been appointed staff engineer for special projects for Parker Appliance Co., Cleveland, to direct development of fuel system accessories and jet engine components. Mr. Overbeke has been active in the aircraft field since 1926, serving with Glenn L. Martin Co. and Great Lakes Aircraft. From 1942 to 1946 he was chief engineer, Simmonds Aerocessories Inc., and prior to joining Parker, Mr. Overbeke was active as a consulting engineer.

new parts and materials

For additional information on these new developments see Page 257

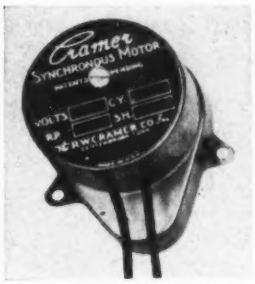
Micrometer Needle Valve



Designed for close control of fluid circuits, micrometer needle valve is threaded 5/16-40 and has a needle with 10-degree included angle. Body of valve is high-strength brass with needle stem of Duronze, machined to close tolerance. Aluminum bodies can be supplied on request. Sizes available include ⅛ and ¼-inch with eight port combinations of male, female, piping and tube connections. Manufacturer: Parker Appliance Co., 17325 Euclid Ave., Cleveland 12.

For further information circle MD 1 on Page 257

Self-Starting Timing Motors

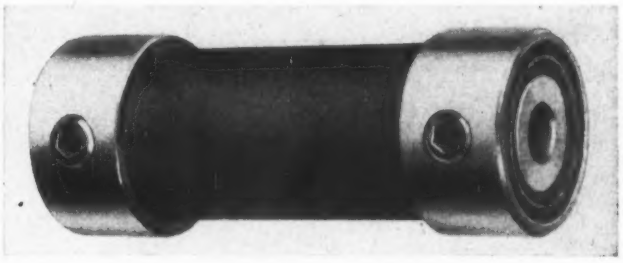


Type SX timing motor is completely self-contained. Designed for use with timing devices, recording and communications equipment, traffic and heating controls, etc., the unit reaches synchronous speed within 2 cycles and will stop within ¼-degree when de-energized. Standard gear trains producing output speeds ranging from 60 rpm to one revolution in 24 hours are available with either plastic or metal gears. Motor is equipped with friction clutch, permitting manual turning of the drive shaft in either direction independent of gear train and motor. One-way friction clutch is available for applications where the driven mechanism must not be turned backward, yet must be set forward manually. Manufacturer: R. W. Cramer Co. Inc., Centerbrook, Conn.

For further information circle MD 2 on Page 257

Flexible Couplings

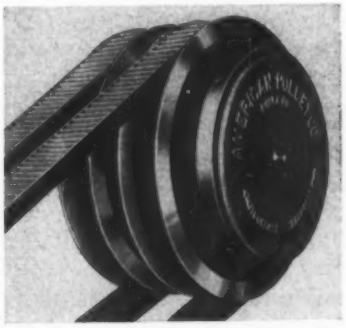
Recommended for use with direct-connected ¼-hp motor drives, type H couplings provide quiet operation since they are of one-piece construction. They are made of heavy-duty rubber-and-fabric hose with bodies of plated steel. Bores range from ¼ to ½



inch. Standard lengths available include 2½, 3, 3½ and 4 inches. Units having larger bore sizes and greater lengths can be made to order. Manufacturer: The Climax Flexible Coupling Co., 863 E. 140th St., Cleveland 10.

For further information circle MD 3 on Page 257

Wide-Range Adjustable Sheave



Adjustable diameter sheave features use of rubber lagging between the hub and the pulley flanges. As a result freezing of the adjusting mechanisms is eliminated since rubber acts as an insulating cushion between the sheave components. Other features of the sheave include quietness, ease of adjustment, small size and dynamic balance. Units are made in two and three-groove types with pitch diameter variation of 5¼ to 10 inches. Adjustment for speed variation is made while the drive is stationary. Using multiple R section V-belts, they are rated at up to 15 hp. Manufacturer: The American Pulley Co., 4200 Wissahickon Ave., Philadelphia 29.

For further information circle MD 4 on Page 257

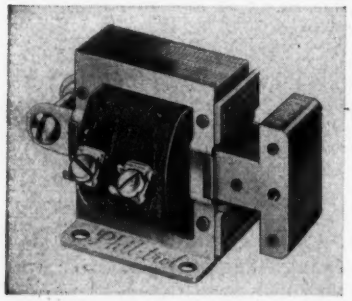
Centrifugal Pumps

Four models of single and two-stage centrifugal pumps are made in capacities ranging from 10 to 2500 gpm with ratings from ¼ to 75 hp. They are suitable for use with fluids having viscosities up to 8000 SSU. The four types consist of: Close-coupled with common shaft; close-coupled with pump mounted on extended motor shaft and pump adapter; pump mounted on base plate with or without motor and flexible

coupling; and self-priming pump mounted on base plate with or without motor and flexible coupling. Pumps are of iron construction with bronze fittings, or all bronze with steel shafts. Impellers may be had in either closed or open types. Manufacturer: Bowser Inc., Fort Wayne 2, Ind.

For further information circle MD 5 on Page 257

Push-Pull Actuator



Solenoid actuator of push-pull type can produce a 17 lb pull. Unit uses a T-shaped plunger and operates on 115-volt 60-cycle current with a maximum stroke of one inch. Smooth and long operating life is assured by nonmagnetic stainless steel side plates on the plunger and brass plunger guides on the inside of the frame. This 51A actuator measures 3½ inches long, 1⅞ inches wide and 1 15/16 inches high. Manufacturer: Phillips Control Corp., 612 N. Michigan Ave., Chicago 11.

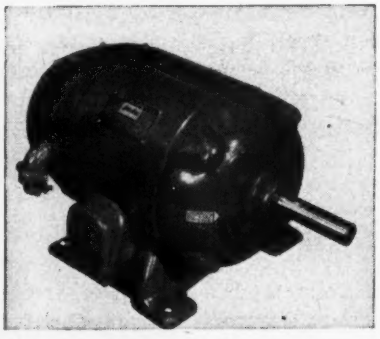
For further information circle MD 6 on Page 257

Corrosion-Resisting Axial-Flow Pump

Designed for handling corrosive liquids such as sea water, axial-flow pump has impellers and suction bells of 25 per cent chromium, 12 per cent nickel stainless steel. Shafts are 18-8 stainless. Elbows are high-test cast iron containing 2 per cent nickel. The pump is particularly suited to applications where increase in capacity, due to decrease in head, is not objectionable. Manufacturer: Economy Pumps Inc., Hamilton, Ohio.

For further information circle MD 7 on Page 257

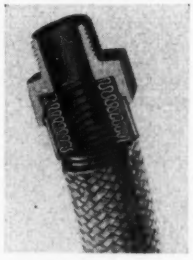
Wound-Rotor Induction Motor



Dripproof line of induction motors is made in ratings of 1 to 15 hp using frames 203 through 326. Of the wound-rotor type, the motors have rolled-steel frames, pressed-steel feet, and pulley end bracket and cast-iron front end bracket. Brushes are electrographite or metallic graphite as required. Units are recommended for applications wherever adjustable speed is required or where high-starting torque with low-starting current is necessary. Balanced design and sturdy construction makes them especially suitable for driving compressors, plunger pumps, and positive pressure blowers, or for bringing heavy loads up to speed. Motors are made for operation on 25, 50 and 60 cycles, 2 and 3-phase current at 208, 220, 440 and 550 volts. Operating speeds, when used on 25-cycle power include: 485, 750 and 1450 rpm. For 50-cycle operation, possible speeds include: 485, 580, 715, 965 and 1450 rpm while speeds of 580, 690, 870, 1160, and 1750 rpm are possible on 60-cycle operation. Manufacturer: Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30.

For further information circle MD 8 on Page 257

Quick-Soldered Hose Coupling

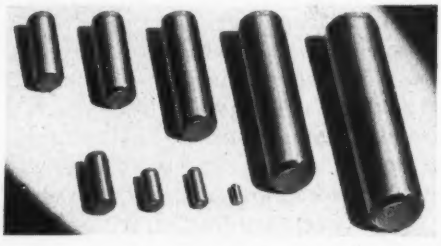


For service at temperatures not exceeding 300 F, the quick-soldered hose coupling consists of two pieces, a male body and a loose collar. Collar is so designed that when hose is cut the flexible-hose braid is held tight, preventing unraveling and slipping. Couplings are available for hose sizes ¼ to 1 inch and have pressure ratings varying from 700 psi for the ¼-inch size to 250 psi for the one inch size. Manufacturer: The Brockway Co., Naugatuck, Conn.

For further information circle MD 9 on Page 257

Rust-Resisting Dowel Pins

Holo-Krome line of dowel pins is now made in a rust-resistant black lustre finish. In addition to providing rust resistance, finish also provides lubrication,

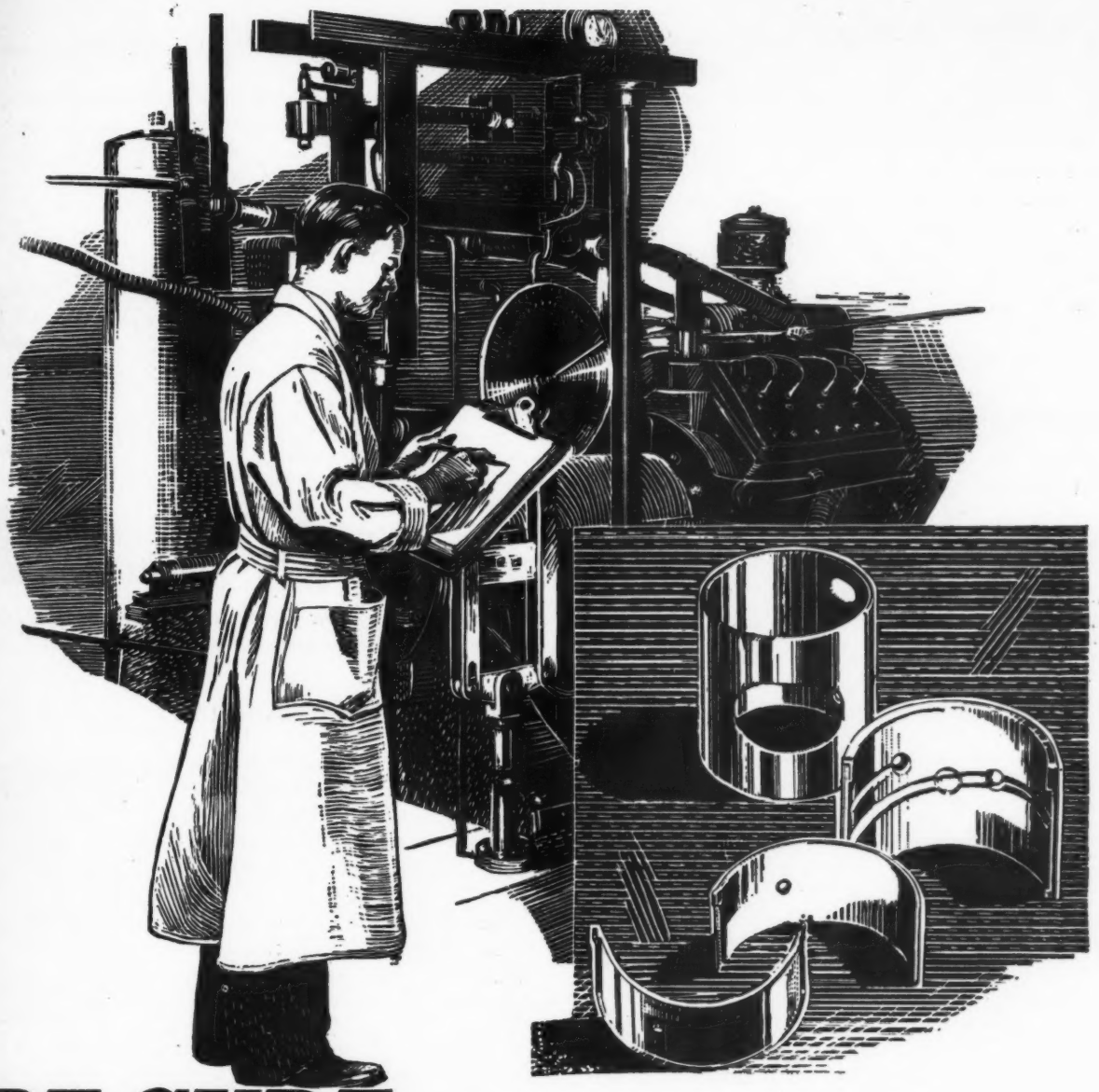


facilitating driving of pins and reducing scoring of the mating parts. Manufacturer: Holo-Krome Screw Corp., Hartford 10, Conn.

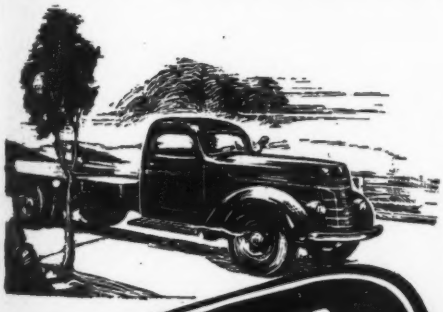
For further information circle MD 10 on Page 257

Self-Supporting Rotary Pressure Joint

Type S rotary pressure joint requires no external piping support. It is self-lubricating, has no packing and adjusts itself for varying pressures. A spherical sealing surface is used to maintain an effective seal even though wear should occur. Weight of the joint is supported by a carbon-graphite bearing accurately fitting inside the joint body where it provides a bear-



BE SURE of Bearing Performance



JOHNSON BRONZE
SLEEVE BEARING HEADQUARTERS
BRANCHES IN 20 INDUSTRIAL CENTERS

JOHNSON BRONZE determines in advance your requirements for a sleeve bearing . . . then designs and produces it to meet these specific conditions.

A bearing leads a tough life. It must be correct in every detail or it will not operate efficiently. The whole mechanism in which it is installed ceases to operate when a bearing fails. Therefore, Johnson Bronze makes sure that each bearing will deliver top performance for the longest period of time at the lowest possible cost. An example . . . automotive bearings. In addition to tests for determining physical and chemical characteristics, Johnson technicians simulate actual operating conditions with dynamometer tests. They go even further. Grueling road tests are run under severest operating conditions. From the facts obtained it is natural that long life and economy are built into Johnson Sleeve Bearings.

You, too, can know in advance that a Johnson Bearing will not fail. Similar technical research is available for your bearing requirements. Why be satisfied with less? Write today for complete details.

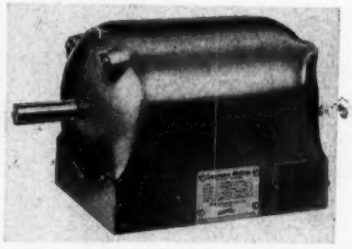
JOHNSON BRONZE CO.

525 S. Mill St., New Castle, Pa.

ing surface on the nipple. Seal proper is effected between a hemispherical collar on the nipple and another carbon-graphite bearing ring. Standard construction offers cast-iron head and body and steel nipple; other styles are available having bronze body, bronze trim or all bronze construction with stainless-steel spring. Four sizes are available—½, ¾, 1, and 1¼ inch; all are suitable for operation at 150 psi and 400 F. Manufacturer: Johnson Corp., Three Rivers, Mich.

For further information circle MD 11 on Page 257

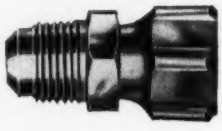
Sanitary Electric Motors



Designed for use in food processing plants, new electric motors are entirely free of cracks and recesses where food products can collect. Small ratings are of totally enclosed nonventilated construction and larger ratings are splashproof. All sizes can be washed down to insure maximum sanitation. A feature of the motor is its flush base construction. Base is enclosed by the motor housing which prevents collection of particles under motor. Manufacturer: Louis Allis Co., Milwaukee 7.

For further information circle MD 12 on Page 257

Rapid Tube Coupling



Tight connection of vacuum or pressure lines may be made without the use of tools by the Electrimatic quick coupler. Finger-grip surface allows firm grasp and slight turn makes connection. The coupler is available in SAE flare sizes from ¼-inch male and female to ⅝-inch male and female. Manufacturer: Electrimatic Div., Simoniz Co., 123 E. 21st St., Chicago 16.

For further information circle MD 13 on Page 257

High-Torque Rotary Solenoids

Two new rotary solenoids develop torques of 25 and 50 lb-in. respectively. The first, known as Ledex No. 7, is 2¾ inches in diameter and weighs 2½ lb. It produces its torque through a 45-degree arc. The larger model, Ledex No. 8, measures 3⅜ inches in diameter, weighs 4 lb and has a 45-degree arc. Both units are of sturdy construction and have optional dustproof cover and return spring. Units are available for operation on voltages from 6 to 550 dc. Rectifiers can be supplied as accessories for operation from alternating current. Manufacturer: G. H. Leland Inc., 151 Webster St., Dayton 2.

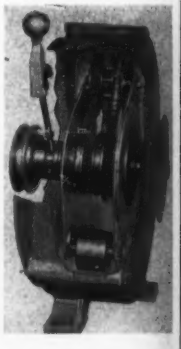
For further information circle MD 14 on Page 257

Pilot-Type Relief Valve

Suitable for use with fluid pressures up to 4000 psi, the No. 1000-3 relief valve has a flat, rather than a rising, characteristic because of the low flow required to actuate the pilot. Capacity is 2½ gpm at 200 psi and 10 gpm at 4000 psi. Measuring 1 by 2½ by 3½ inches the valve weighs 8½ oz. Manufacturer: Fluid Controls Inc., Willoughby, Ohio.

For further information circle MD 15 on Page 257

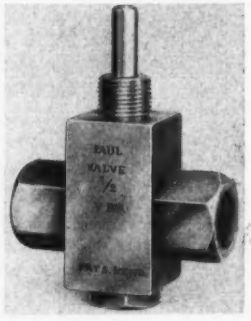
Variable-Speed Transmissions



Transmissions offered as the Speed Selector line, are now made in 5 hp capacity. The units use V-belts operating in cast-iron sheaves and mounted in cast-aluminum housings. Speed range is infinitely variable from 0 to 800 rpm and reverse. Clutches, multispeed motors and gear shifts are obviated. Either V-belt or flexible coupling input or output are optional. Manufacturer: Speed Selector Inc., 118 Noble Court, Cleveland 13.

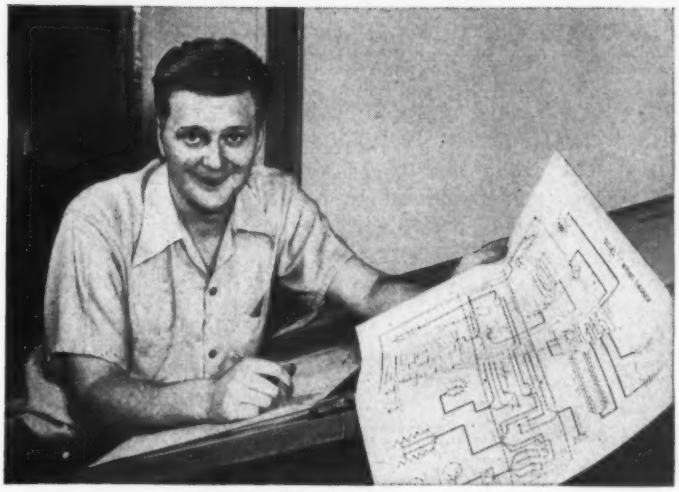
For further information circle MD 16 on Page 257

Sensitive Ball-Type Valve



For use with machines having automatic sequencing of valves, the Paul straight-through automatic valve opens with a light push on the stem. Valve makes use of the venturi principle to seat ball, low pressure area in center of fluid stream automatically forcing the ball into its seat when it is mechanically deflected into the low-pressure area by the yoke. Conversely, valve is opened by displacing the ball into a recess, and out of the stream so that it does not restrict fluid flow. Little force is required to seat and unseat the ball, the stream supplying most of the energy. As a result the unit is unusually sensitive and can be operated

A new future for your drawings!



1. Now any of your drawings can be reproduced in black, blue, red, or sepia lines on white or tinted paper. Thus, you can "color code" your prints . . . speed routing . . . eliminate errors.

2. You can always match the job at hand. For example: If grease and grime abound in the shop you can practically eliminate replacements by ordering Ozaplastic prints.

These durable prints are oilproof, waterproof—can be cleaned in seconds with a damp cloth.

3. You can improve on your best drawing by ordering Ozacloth or Ozalith translucent "masters." These new materials increase the line densities of your original . . . are plastic-coated . . . oilproof, waterproof . . . turn out Ozalid prints of maximum visual density.

4. New Ozalid Stripfilm—a transparent, adhesive-back material—can be used to transfer title blocks, sections, etc., from one drawing or master copy to another.

Using Ozalid foils, you can combine on *one* print the details of separate, but related, drawings. And new Ozachrome even allows you to make transparent overlays in full color.

Always the same simple operation—Exposure and Dry Development—to produce the desired type of Ozalid print.

And speed? Standard Ozalid prints are produced in 25 seconds—or less! Each a positive copy produced directly from your original drawing.

New Free Booklet!

See all the Ozalid prints you can make . . . and learn specifications of complete line of Ozalid machines. There's *one* for you.

DEPT. NO. 131

OZALID A Division of General Aniline & Film Corporation
Johnson City, New York

Gentlemen: Please send free booklet of Ozalid prints . . . and machine catalog for all printmaking requirements.

Name_____

Position_____

Company_____

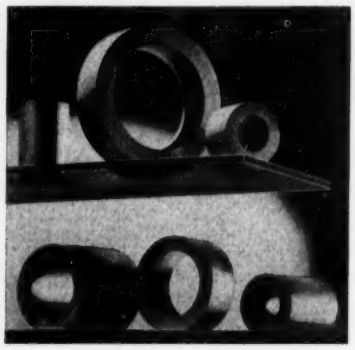
Address_____

Ozalid in Canada—Hughes Owens Co., Ltd., Montreal

by solenoid or diaphragm. This type VBA valve is made in ½, ¾ and 1-inch sizes with standard NPT connections suitable for pressures up to 125 psi. Capacity with 20 per cent down-stream pressure at 50 psi is 25 gpm. Manufacturer: Paul Valve Corp., 683 3d Ave., New York 17.

For further information circle MD 17 on Page 257

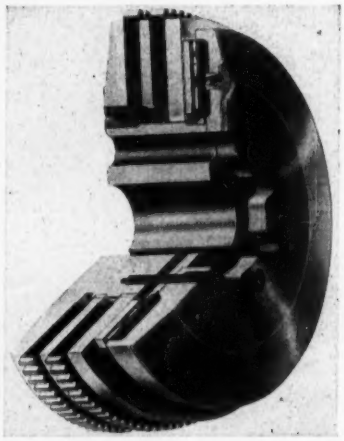
Standard Carbide Bushings



Line of standard carbide bushings is made in two size classifications. Group A are short, ranging from ⅛ to ½-inch in length and 1/16 to 1 inch in inside diameter. Group B are comparatively larger, ranging from ⅞ to 1 inch in length, ⅜ to 2⅜ inches in inside diameter and 11/16 to 3 inches in outside diameter. The smaller size bushings in group A are standard in Carboloy grade 883 and the balance in this group as well as those in group B are Carboloy grade 44A. Manufacturer: Carboloy Co. Inc., 11177 East 8-Mile Rd., Detroit 32.

For further information circle MD 18 on Page 257

Heavy-Duty Disk Clutch



Air-Tube disk clutch has large capacity for its size and is unaffected by centrifugal force. Operating means is annular tube to which air pressure is applied. This expands the tube and engages the plates of a single or multiple-disk clutch. Units are available in 18, 24 and 30-inch single and double-plate sizes having hp capacities from 40 to 1000. Manufacturer: Wichita Falls Foundry and Machine Co., Wichita Falls, Texas.

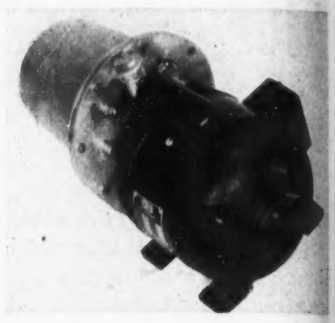
For further information circle MD 19 on Page 257

Woven-Wire Conveyor Belt

Designed for industrial washing, drying or cooling applications, woven-wire conveyor belt has 87 per cent open area while retaining high strength. Belt can be made of any metal or alloy in a wide variety of mesh openings. Types are available for use with sprocket or roller drive. Manufacturer: Cambridge Wire Cloth Co., Cambridge, Md.

For further information circle MD 20 on Page 257

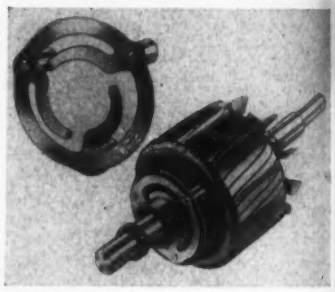
Miniature Hydraulic Units



Suitable for automatic or remote control of hydraulic cylinders, miniature hydraulic unit includes a pump, reservoir, valves and electric motor. Styles are available for operation on 110, 220, 440 volt single or polyphase current to produce a wide variety of flow and pressure. Manufacturer: John Dusenbery Co., 150 Pine St., Montclair, N. J.

For further information circle MD 21 on Page 257

Centrifugal Starting Switch

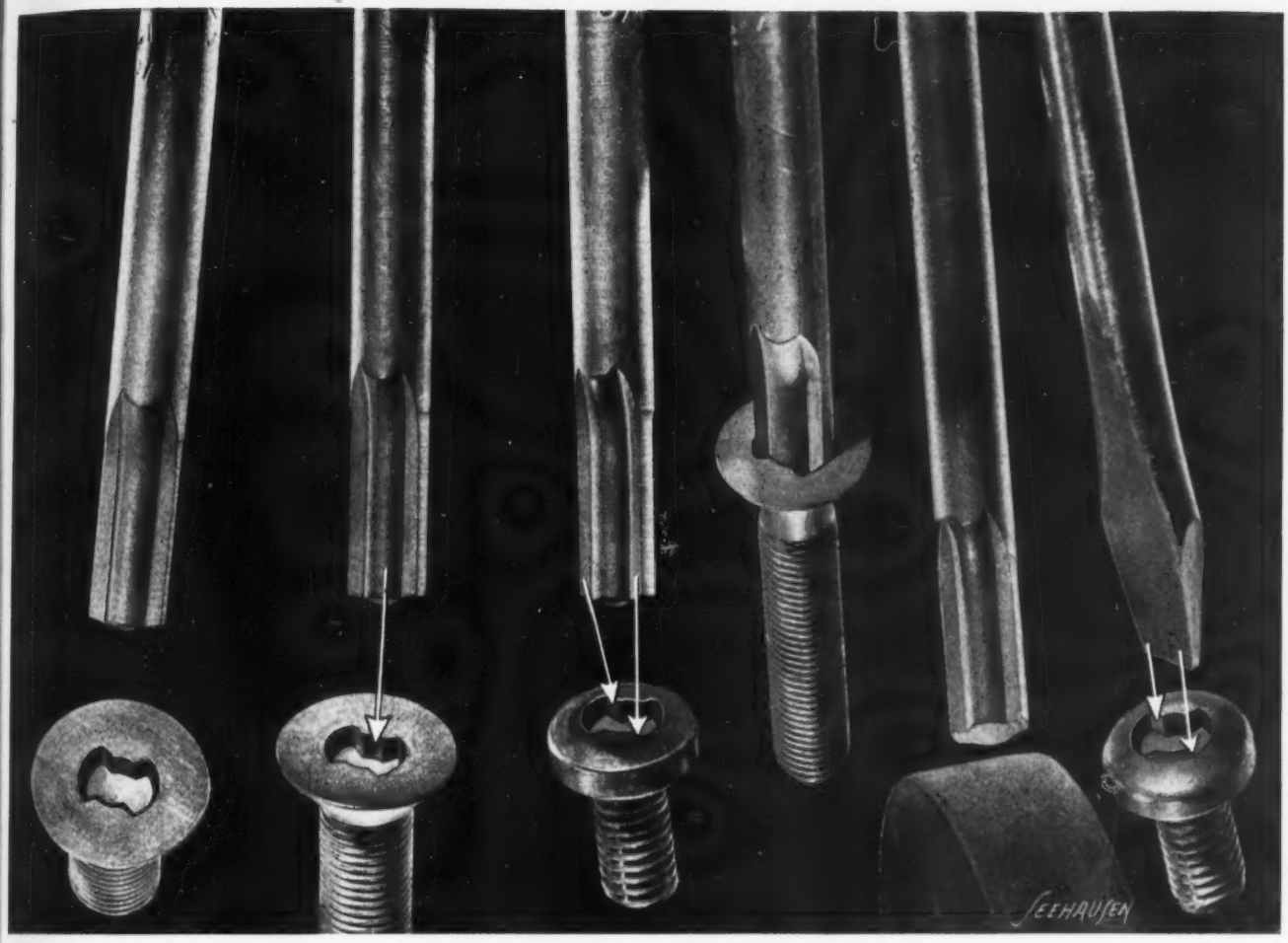


Centrifugal motor starting switch, known as the Syncrosnap, consists of simple disk - shaped stamping with weights attached to the outer edge of the disk. There are no hinged parts linkages or springs used. Movement is preset for operation at the point of maximum torque and is uniform throughout the life of the motor. Switch actuation is of the snap type reducing arcing and providing definite contact. Manufacturer: Torq Electric Corp., 1075 Interstate St., Bedford, O.

For further information circle MD 22 on Page 257

Percentage Timer

Type PE timer is designed for use on alternating current to control automatically the percentage of time at which any electrical circuit can be closed or open out of a definite length of time. It is used to regulate the input to such equipment as furnaces, blowers, pumps and lubricators, and is made in types calibrated in the range 4 to 96 per cent in one per cent steps. Twelve speeds are available—from one revolution in 15 seconds to one revolution in 24 hours. The switch is of the totally en-



Here's How CLUTCH HEAD *Brings Slow-down To A Show-down...*

. . . the slowdown resulting from the use of fastener equipment that fails to measure up to the high speed tempo and safety requirements of today's modern assembly line production.

The Slowdown Of Poor Visibility is countered by CLUTCH HEAD'S wide roomy recess . . . an easy-to-hit target that inspires confidence and speed . . . even with "green" operators.

The Slowdown of Burred and Chewed-up Heads, the result of driver canting, is checked out by CLUTCH HEAD'S Center Pivot entry in dead center for automatic straight driving.

The Slowdown of Skid-Fear is eliminated by non-tapered driving engagement . . . exclusively a CLUTCH HEAD feature . . . Note the straight sides of the bit that engage the straight walls of the recess for absence of dangerous "ride-out" as set up by tapered driving.

The Slowdown of Refinishing Skid Damage takes a heavy toll of time and money. The safety and certainty of CLUTCH HEAD'S non-tapered driving is credited by users with *the elimination of damage* to fine surfaces.

The Slowdown of Operator Fatigue is also cancelled out by the non-tapered drive. No "ride-out" means easier, smoother driving with no end pressure to combat . . . therefore, no end-of-the-shift lag.

The Slowdown of "Fumble Spots," involving two-handed reaching into inside spots, is solved by the CLUTCH HEAD Lock-On. A simple reverse turn unites screw and bit as a unit for one-handed driving and easy access to inside assembly points.

The Slowdown of Tool Changing is offset by the rugged structure of the Type "A" Bit which has an established record of driving 214,000 screws non-stop. Note too, that this bit may be *repeatedly restored* to original efficiency by a 60-second application of the end surface to a grinding wheel.

The Slowdown of Field Service is checked out by the basic design of the Clutch Recess for operation with a common screwdriver or any flat blade . . . which need only be reasonably accurate *in width.*

CLUTCH HEAD · SCREWS ·

Only America's Most Modern Screw offers this unique combination of features. Send for screw assortment, sample Type "A" Bit, and illustrated Brochure. Make your own appraisal and you will understand why users report production increases ranging from 15% to 50% over all other screws . . . recessed heads and hexagons, as well as slotted.

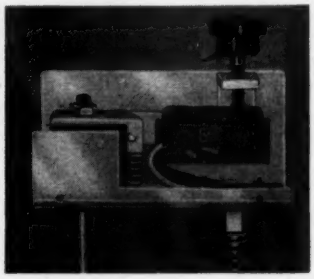
UNITED SCREW AND BOLT CORPORATION

CLEVELAND 2 CHICAGO 8 NEW YORK 7

closed fast-action type rated to handle a 1/3-hp motor load or solenoids in which the inrush does not exceed 15 amperes at 110 volts. Manufacturer: R. W. Cramer Co., Centerbrook, Conn.

For further information circle MD 23 on Page 257

Thermostatic Switch



Model L temperature-control switch is suitable for use at temperatures to 3350 F and above. At these temperatures it has an operating differential of plus or minus 2 to 5 degrees while at the low temperatures the differential is plus or minus ½ degree. The switch is made with flexible conduit and twist lock clip or with other types of plug-in connectors as per specifications. Manufacturer: Burling Instrument Co., 253 Springfield Ave., Newark 3, N. J.

For further information circle MD 24 on Page 257

Plated Aluminum Sheet

Nickel and chrome-plated aluminum sheet is made in sizes up to 36 x 96 inches in wide ranges of tempers and gages. Plating gives the aluminum a hard, long-wearing finish and resistance to tarnish. In addition, the material can be soldered. Manufacturer: American Nickeloid Co., Peru, Ind.

For further information circle MD 25 on Page 257

Ball-Handled Adjusting Screw

Adjusting screw with double-ball handle is particularly suitable for use in applications where considerable hand leverage must be applied. Of welded construction, the screws are made of low-carbon or stainless steel with handles three inches or more in length. Standard thread sizes include: ¼, 5/16, and ⅜-inch, No. 8 and 10. Manufacturer: Ohio Nut and Bolt Co., 600 Front St., Berea, Ohio.

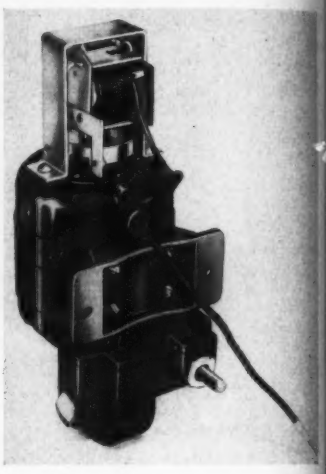
For further information circle MD 26 on Page 257

Rubberlike Plastic

Having many rubberlike characteristics as well as resistance to hydrocarbon solvents, FE-1044 Nylon strip is particularly suitable for use as oil seals and valve seating disks in oil lines. The material is nonswelling in contact with many chemicals and possesses outstanding wear resistance properties. It is available in strip form in widths up to 2 inches and thicknesses from 0.015 to 0.125-inch. Manufacturer: The Polymer Corp., 402 Walnut St., Reading, Pa.

For further information circle MD 27 on Page 257

Braking Type Gearmotor



Featuring a magnetic brake that provides instantaneous stop, the No. 1100 gearmotor is suitable for operation on 115-volt 50-60 cycle current. It is made in outputs up to 1/20-hp and has segmented armature insulated to endure a 1000-volt ground test. Motor has die-cast case finished in any one of a variety of colors and two-speed built-in governors are available if desired. Manufacturer: Lextro-Max Inc., Div. of Magar Home Products Inc., Geneva, Ill.

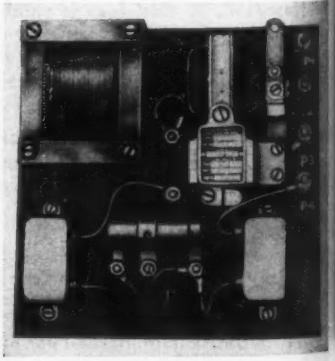
For further information circle MD 28 on Page 257

Sintered Alnico-5 Magnets

As the result of the development of a new process it is now possible to make magnetic components of sintered Alnico 5. Intricately shaped magnets can be made with higher external energy than heretofore possible. The material has high tensile properties and can be produced with smooth surfaces and close dimensional tolerances. Manufacturer: General Electric Co., Pittsfield, Mass.

For further information circle MD 29 on Page 257

Noncreeping Voltage Relay

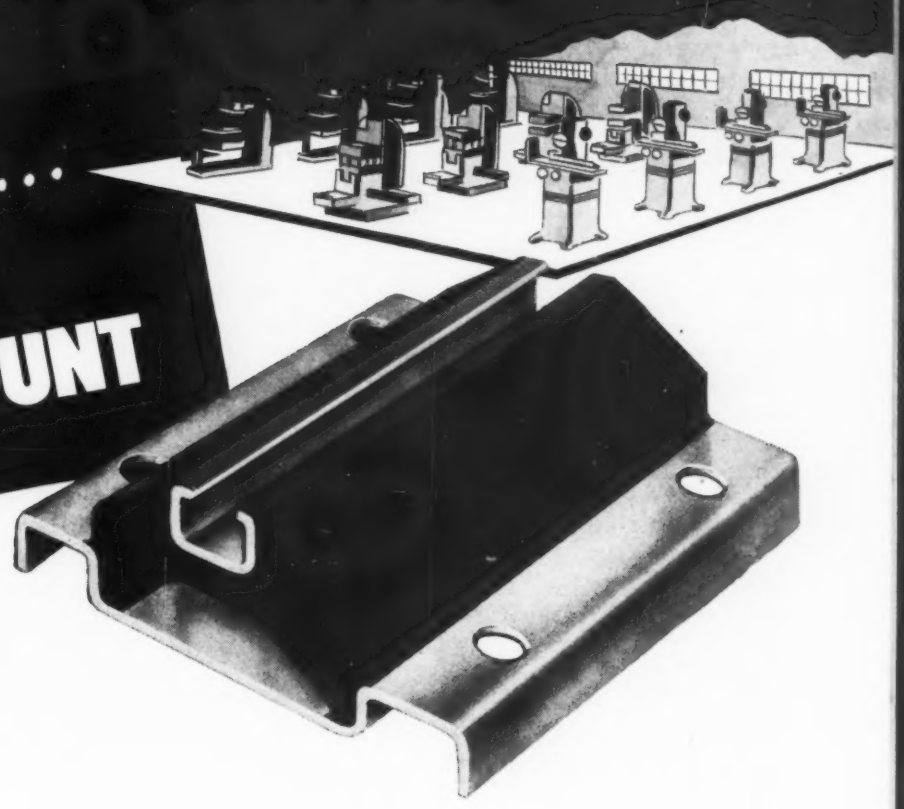


Designed for use on systems to protect equipment against low voltage, noncreeping voltage relay has adjustment range from 75 to 93 per cent drop out and 95 per cent pickup. Contact capacity is 5 amperes at 250 volts ac. Maximum number of poles is two normally open and two normally closed. Known as No. 107S1, the relay is of the positive make and break type with no tendency to creep

Now . . .

with the NEW . . .

LORD CHAN-L-MOUNT



TYPICAL APPLICATIONS

- Pumps
- Air Compressors
- Blowers
- Business Machines
- Motor Generators
- Stationary Engines
- Shakers
- Air Conditioners
- Refrigerators

Various Bulletins available on Vibration Control Mountings, Flexible Couplings and Bonded Rubber Products. For applications providing vibration isolation regardless of direction of disturbing forces, Bulletin No. 106; for applications isolating vibration but not subject to intense shock, Bulletin No. 104; for applications involving transient shock loads in addition to vibration, Bulletin No. 103; Flexible Couplings, Bulletin No. 200-C; Shockmounts, Bulletin 400.

Vibration Control is easily accomplished with Lord Chan-L-Mounts. Vibration in the mounted machine is effectively controlled . . . and neighboring machines protected from transmitted vibration.

Chan-L-Mounts may be used for a wide variety of light and medium weight machines. There are no special fixtures, no holes to drill. The channel holds the bolt head firmly in place and the nut is quickly tightened with a single wrench. The flexing element is designed to control vibration caused by occasional shock load and impact as well as that of normal operation. A substantial section of soft rubber beneath the supporting channel protects against metal-to-metal bottoming . . . the rigid, one-piece base prevents spreading under load. Minimum stress on rubber-to-metal bond means longer life.

Lord Chan-L-Mounts are available in convenient sizes . . . ready for installation. A modest inventory of Chan-L-Mounts gives you ready-to-use vibration control when you need it, where you need it. Write for Bulletin 300.

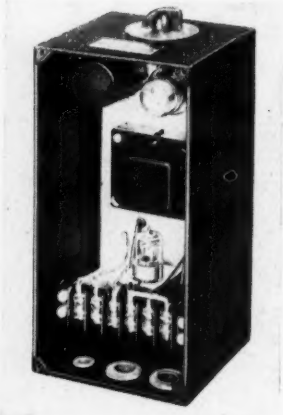
LORD

Vibration Control

on opening or closing. Adjustments are provided to permit field variation of factory setting. Manufacturer: Automatic Switch Co., Orange, N. J.

For further information circle MD 30 on Page 257

Electronic Temperature Controller



Using an electrical resistance type thermal pickup, new electronic temperature controllers are suitable for use in remote control systems. Units are available to cover the temperature range from −100 F to +1200 F and are adjustable within a range of several hundred degrees. They are nonindicating. Supply voltage may be 115 to 230 volts, 50-60 cycle current. Load capacity is 30 amperes at 115 volts, 20 amperes at 230 volts. Normal response time is under three seconds. A 5 x 5 x 10-inch control panel weighs less than 8 lb. and is provided with conduit knockouts and terminal board. Manufacturer: Instrument division, Thomas A. Edison Inc., West Orange, N. J.

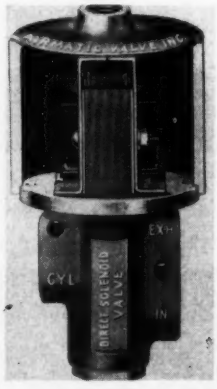
For further information circle MD 31 on Page 257

Plastic Pipe

Made of Kralite, a blend of synthetic rubber and thermoplastic resins, plastic pipe is available in rigid and semi-rigid forms in sizes ranging from ¼ to 2 inches outside diameter. Having no metal or fabric reinforcement the pipe can readily be bent to small radii or threaded for fittings. Manufacturer: United States Rubber Co., Rockefeller Center, New York.

For further information circle MD 32 on Page 257

Three-Way Solenoid Valves



Mountable in any position, new solenoid-operated three-way valves are suitable for operation on 110-volt 60-cycle current and are rated 1.42-amperes inrush and 0.22-amperes holding current. They are precision machined and corrosion resistant and are designed to permit maximum fluid flow. Sizes in which this model DS-3 valve is available include: ¼, ⅜, ½, 1, 1½, 2, 2½ and 3 inches. Manufacturer: Airmatic Valve Inc., 1643 E. 40th St., Cleveland.

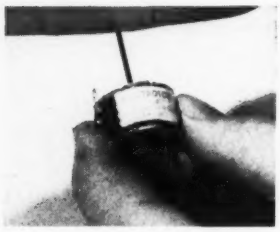
For further information circle MD 33 on Page 257

Motor-Starting Relay

Motor-starting relay of the series type has balanced armature permitting operation in any position. This new design also incorporates beryllium - copper leaf springs which are independently adjusted for pick-up and dropout, providing dependable operation over a voltage range of 90 to 130. The unit is enclosed in a phenolic case with either screw or solder terminals. Dimensions are 1⅞ x 1 15/16 x 5/16 inches. Manufacturer: RBM Division of Essex Wire Corp., Logansport, Ind.

For further information circle MD 34 on Page 257

Miniature Electric Motors

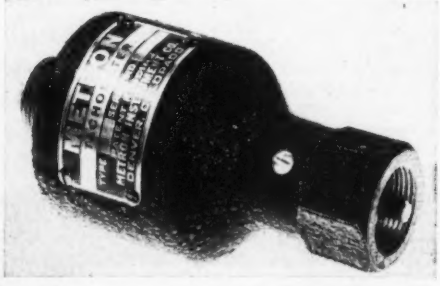


New line of miniature electric motors operate on the gap ring principle and require no commutator. Smallest of the line is type 240 which operates at 5000 rpm on 3 to 4½ volts. This unit measures ⅞-inch in diameter and 9/16-inch long and weighs ¾-oz. Known as Electromotors, the devices consist of a gap-ring armature winding mounted on a bobbin and spindle. These revolve within a permanent ring magnet and commutation is achieved by direct contact with the armature. Typical applications include electric shavers, automotive accessories, radio-controlled devices and motion picture cameras. Manufacturer: United States Instrument Corp., Summit, N. J.

For further information circle MD 35 on Page 257

Lightweight Tachometer Head

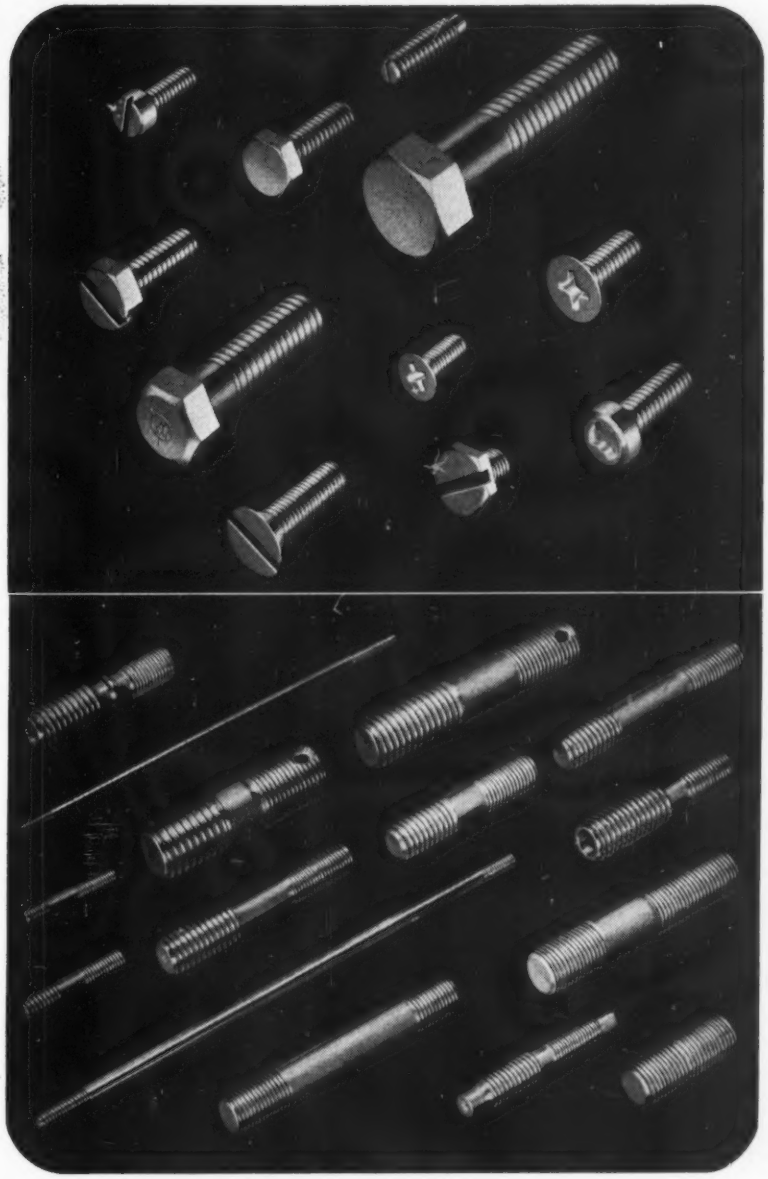
Type 54 tachometer heads are designed for use with standard marine, aircraft and diesel tachometer takeoffs. They provide full scale readings as low as



200 rpm or as high as 10,000 rpm, yet measure only 2⅛ inches in diameter and 4⅜-inches long. Operating on a contact principle, the heads have no gears

The uses of "LOK-THRED" are unlimited

STUDS, BOLTS OR SCREWS LOCK MORE SECURELY... BECOME *TIGHTER* IN SERVICE... FORM A SEAL THAT LIQUIDS UNDER PRESSURE CANNOT PENETRATE



The revolutionary "LOK-THRED" that has proved so successful in stud applications can now be made in any type of threaded fastener.

Now the uses of "LOK-THRED" are unlimited. Whether you need a tiny screw or a heavy-duty bolt, you can have the headed fastener you want—threaded with "LOK-THRED".

With the positive sealing action of "LOK-THRED", bosses and blind tapping can be eliminated in many cases. Air and liquids are held under pressure without leakage—suggesting many new uses, such as for water pumps or for cylinder heads.

Write for "LOK-THRED" booklet, today.

Look at all these Advantages

1. Lock securely and become tighter in service.
2. Have much higher fatigue limits than studs with conventional threads.
3. Stronger in both tension and torsion than ordinary American National Threads.
4. Carry entire normal working load on 6° angle at root of thread under high compressive prestress.
5. Modified American National Threads permit use of standard tools.
6. Re-usable and on any reapplication less than one-half additional turn brings torque back to its original installation value.
7. Do not require selective fits.
8. Do not gall when being driven or fret in service.
9. Act as dowels and taper pins.
10. Seal positively and eliminate added bosses and blind tapping.

National PRODUCTS

THE NATIONAL SCREW & MFG. COMPANY, CLEVELAND 4, OHIO

or brushes and are unaffected by vibration, magnetic fields or temperature variations over a wide range. Operating torque is approximately 1/20-oz-in. for high-speed types and ⅛-oz-in. for low-speed types. Manufacturer: Metron Instrument Co., 432 Lincoln St., Denver 9.

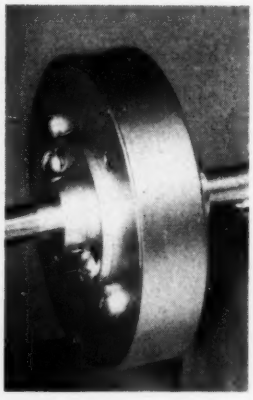
For further information circle MD 36 on Page 257

Protective Organic Finishes

Line of protective organic finishes is suitable for application on appliances. Designated Kemclad appliance finishes, they feature opacity, build, good color stability and retention; and resistance to fruit acids, humidity and soap-water immersion. The finishes will withstand temperatures as high as 400 F for short time intervals. Manufacturer: Sherwin Williams Co., 101 Prospect Ave., Cleveland 1.

For further information circle MD 37 on Page 257

Automatic Clutch

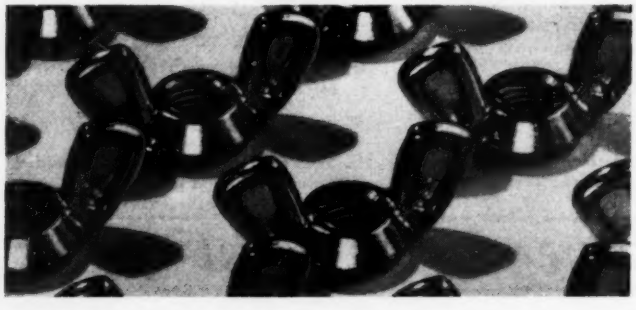


Suitable for use on applications transmitting up to ¼ hp, the Clark clutch has a controlled slip period providing longer life and more efficient clutch performance. The unit is actuated by centrifugal force and controlled by automatically changing moment arms during clutch engagement. Starting torque is thereby increased, while overload is taken care of automatically. Clutch measures 3⅛ inches in diameter and 1⅝ inches wide and weighs ¾-lb. Shaft sizes available are 5/16, ⅜, 7/16 and ½-inch. Manufacturer: Clark Clutch Div., All Steel Welded Truck Corp., Rockford, Ill.

For further information circle MD 38 on Page 257

Zinc-Alloy Wing Nuts

Line of rustproof zinc-alloy wing nuts are made in sizes from No. 4 to ½-inch. They are corrosion resistant and free of rough edges and feature recessed wings to provide finger grip. The threads are tapped. In addition to a bright finish, the nuts are made in all commercial finishes. Manufacturer: Gries Reproducer Corp., 793 E. 132 St., New York 54.



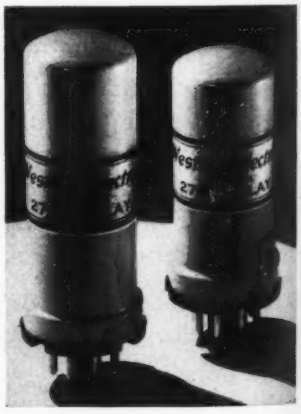
For further information circle MD 39 on Page 257

Vertical-Shaft Gasoline Engine

Die-cast, single-cylinder gasoline engine is rated 2½ hp at 2500 rpm. It weighs 24 lb. An oil-bath air cleaner and a visible-sediment type fuel filter protect the engine against dust and other air-borne abrasives. Design of the engine, using vertical shaft, permits direct coupling to a wide variety of portable machines. Manufacturer: McCulloch Motors Corp., 6101 W. Century Blvd., Los Angeles.

For further information circle MD 40 on Page 257

High-Speed Relays

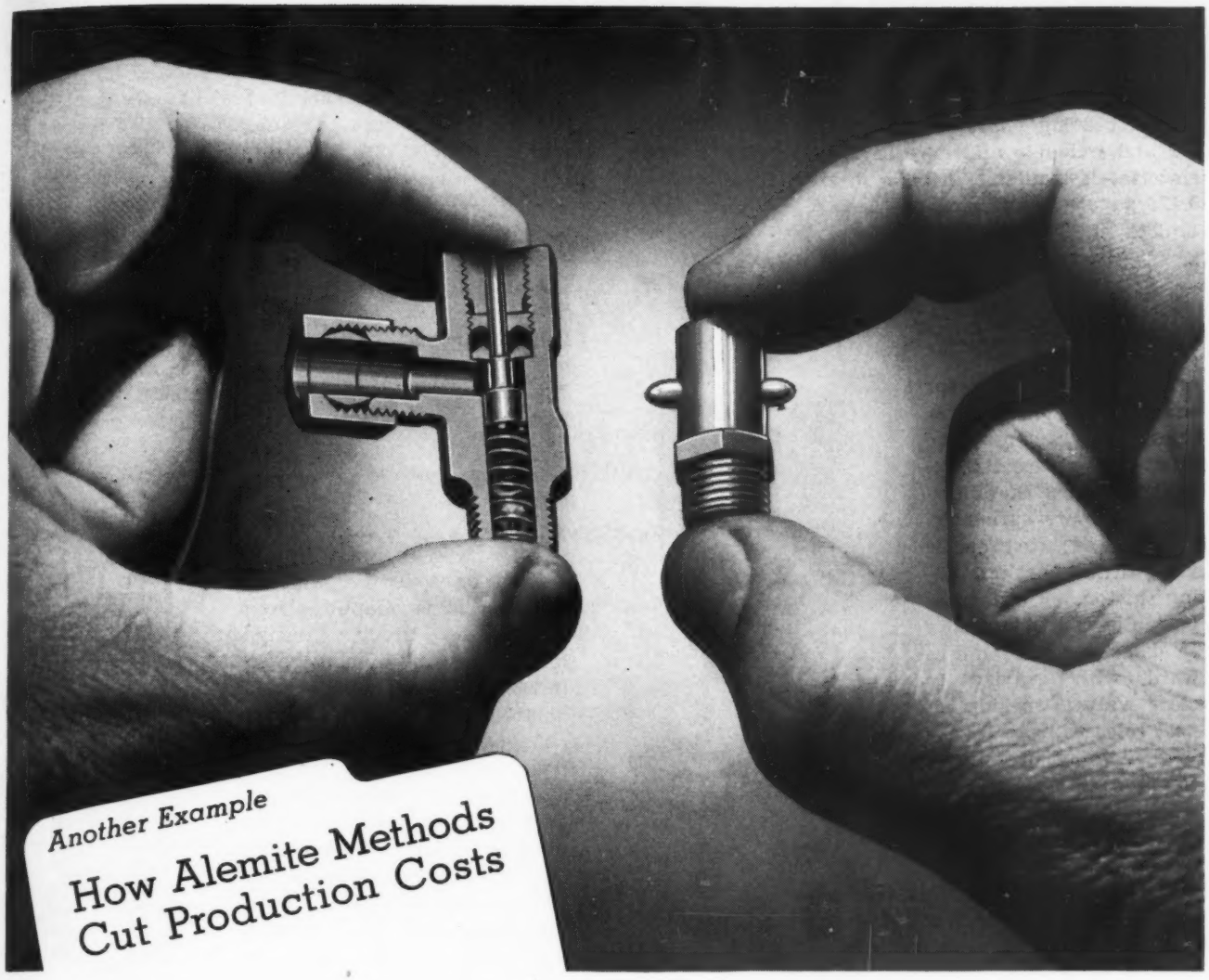


Mercury-contact relays are hermetically sealed and are particularly suitable for high-speed operation under adverse atmospheric conditions. They feature small size, high sensitivity and consistency of operating characteristics. The mercury provides low contact resistance, serves to dampen undesirable modes of vibration and eliminates chatter. Two types, 275 and 276, suit a wide range of application problems. Manufacturer: Western Electric Co., 195 Broadway, New York 7.

For further information circle MD 41 on Page 257

Cupro-Nickel Condenser Tube

Made in wire form, Ampcoloy 49 cold-heading alloy is a new aluminum bronze developed for the production of small parts. Advantages of the material in-



"Midget" Centralized Lubrication System Helps Machines Produce More

A LOW COST SYSTEM THAT'S HARDLY LARGER THAN AN ALEMITE PIN-TYPE FITTING

Protect Those Machines You Design from Human Error

Human error in lubrication can easily destroy the efficiency of the best designed machine. A five minute conference with an Alemite Representative may well reveal lubrication design features that will make your machines produce more. This man is fully qualified to help you because he is a specialist in modern methods of handling and applying lubricants. Write to Alemite, 1804 Diversey Parkway, Chicago 14, Illinois.

Small, Simple, Compact . . . this new Alemite "Midget" measuring lubrication valve is designed for all types of heavy, light and precision machines—especially where space limitations are encountered. With this single line system, valves mounted on or near the bearings deliver a measured amount of lubricant from one safe, central point while machines keep right on producing!

Alemite Centralized Lubrication Systems make possible the lubrication of hundreds of bearings from one central point—greatly reduce the possibility of "human error". There is no danger of over-lubrication or under-lubrication . . . handles grease or oil. Oilers work in complete safety. Result: Production goes up . . . costs go down.

Just one of many ways that Alemite Methods help industry add productive time to machines with faster, more efficient lubrication equipment and procedures. The Alemite Representative can show case after case where a time study analysis has proved that his methods reduce costs. These methods eliminate costly, time-consuming handling of oils and greases . . . slash "time-out" for lubrication . . . keep dirt and moisture out of lubricants . . . completely mechanize lubrication from barrel-to-bearing. These benefits all add up to lower production costs and longer machinery life. Get the complete facts, today.

ALEMITE

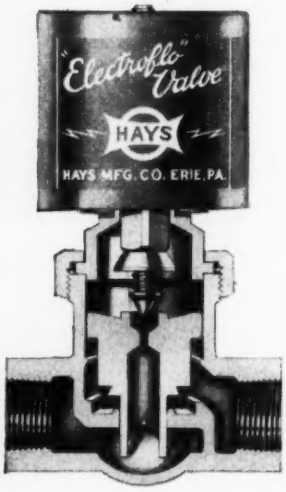
Another Product of STEWART WARNER

MODERN LUBRICATION METHODS THAT CUT PRODUCTION COSTS

clude high tensile strength, resistance to wear and excellent bearing characteristics. It is work hardening and weldable and may be hot forged if desired. Material is available in coils in sizes from 0.125 to 0.420 gage. Manufacturer: Ampco Metal, Inc., 1745 S. 38th St., Milwaukee 4.

For further information circle MD 42 on Page 257

Self-Closing Solenoid Valve



Solenoid type valve for use in oil, gas or water lines is self closing in the event of power failure. Unit works on the differential-pressure principle, solenoid - actuated needle valve fitting port in floating piston. Closing of port allows line pressure to displace piston downward with gravity to close valve; opening of port releases pressure behind floating piston, to force piston upward, opening valve. Since the normal position of solenoid - actuated needle valve places the unit in the closed position, the valve will "fail safe." Manufacturer: Hays Mfg. Co., Erie, Pa.

For further information circle MD 43 on Page 257

Multichannel Photoelectric Counter

Counting system consists of ten photoelectric detectors operating in parallel and connected to a single high-speed electronic counter. Circuits are designed to resolve simultaneous or random counts in ten counting channels, and will provide high-speed predetermined counts to absolute accuracy. By means of this apparatus, up to ten rows of parts can pass the counter simultaneously and the number totalized. Thus a feeder can operate at low speeds while the counting is accomplished at high rates. Also, machine can be set to interrupt flow at a predetermined number of counts. Typical applications include packaging machines, printing presses and machine operations. Manufacturer: Potter Instrument Co. Inc., 136-56 Roosevelt Ave., Flushing, N. Y.

For further information circle MD 44 on Page 257

Rivetless Brake Lining

Applicable to type M magnetic brakes, new brake shoe utilizes a vise type clamp to hold the lining in place and prevent it from shifting. Clamp consists of a permanent buttress at the lower edge and a screw jack at the top edge. The lining is forced into the curvature of the shoe and held firmly in place by tightening the jack. Manufacturer: Cutler-Hammer Inc., 328 N. 12th St., Milwaukee 1.

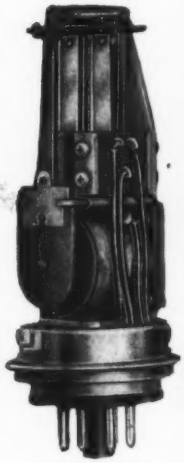
For further information circle MD 45 on Page 257

Stainless-Steel Strip

Bright-annealed cold-rolled strip is now available in the 18-8 analysis. User is therefore able to eliminate the polishing and buffing operations previously necessary. The strip is being offered in widths up to 7½ inches and thicknesses from 0.001 up. Manufacturer: The Cold Metal Products Co., Youngstown, O.

For further information circle MD 46 on Page 257

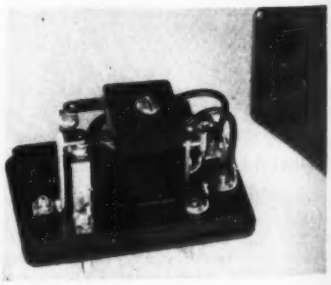
Multiple-Arm Relays



Line of sensitive multiple-arm relays is adaptable to a variety of circuit arrangements. Features include: Minimum mounting area, vertical balanced armature, interchangeable-unit contact pile-ups, high contact pressures, and shock and vibration resistance. Three styles of assemblies are made: Octal socket and dust cover, octal socket and hermetically sealed cover and header-type cover hermetically sealed. Coil types are suitable for d-c operation on 6 to 115 volts at 2 watts, and a-c operation on 6 to 230 volts. Typical circuit arrangements include single-pole, single and double-throw in normally-open and normally-closed units. Manufacturer: Dept. 50-83, Signal Engineering and Mfg. Co., 154 W. 14th St., New York, N. Y.

For further information circle MD 47 on Page 257

Plug-In Relay



Designed for use with equipment that requires fast servicing, the new Grayhill relay has plug-in type connectors which allow the unit to be inserted into a receptacle mounted on a machine. Relay components are mounted on a flat, rectangular molded-phenolic base, on the bottom of which the pin type plug connectors are affixed. A removable molded-phenolic cover, which is optional, makes a tight fit with the base. The units are available in several contact arrangements including single-pole, single and double-

NATIONAL OIL SEAL LOGBOOK

KEEPING NEW DESIGNS FLEXIBLE SAVES COSTLY PARTS ENGINEERING AND TOOLING

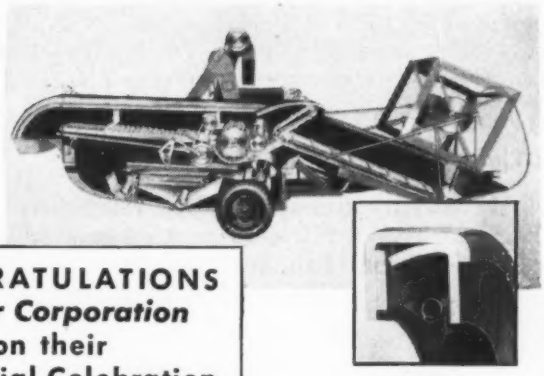


Figure 1

CONGRATULATIONS
Oliver Corporation
on their
Centennial Celebration

A prime example of advantages gained by flexibility of design in preliminary stages is the Oliver Corn Picker. Here, because original designs allowed for incorporation of stock National Oil Seals, a good many dollars and a lot of time were saved. A surprisingly large number of oil sealing problems can be answered in this way.

Oliver Model 5 Corn Master and Model 15 Grain Master Combine utilize identical National seals

Naturally, these Oliver farm implements require carefully engineered mechanical design, because of the rugged treatment to which such equipment is subjected. Bearing protection is of great importance if long-term, trouble-free performance is to be realized. Both the Corn Master and the Grain Master employ many stock National Oil Seals. (See Fig. 1.)

Stock seals are as carefully engineered as special designs

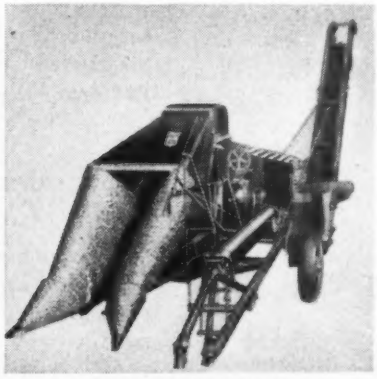
The utilization of stock seals offers the manufacturer great safety in performance because stock numbers have been thoroughly field-tested in other equipment over periods of many years. Of course, there are many sealing problems that can only be solved by special engineering. The sole engineering difference between stock and special designs is that the latter are generally developed to answer problems involving mechanical and operational extremes.

Thousands of stock National Oil Seals are available

Hundreds of different National Oil Seals are now in stock, while dies for thousands more are instantly available. Stock seals include those with leather, synthetic rubber or felt sealing members, combinations of these sealing members, single-wipe and double-wipe seals, tandem or opposed, spring-loaded or spring-less, face-type or shaft-type seals.

Detailed information is readily available. Contact the nearest National Field Engineer or write direct to our Redwood City, California, office.

Oliver Model 15 Grain Master



Oliver Model 5 Corn Master

NATIONAL
OIL AND FLUID SEALS ®

NATIONAL MOTOR BEARING CO., INC.

General Offices: Redwood City, California
Plants: Redwood City and Los Angeles, California; Van Wert, Ohio

CALL IN A NATIONAL ENGINEER FOR RECOMMENDATIONS

BUFFALO: 56 Arlington Place, Grant 2280. **CHICAGO:** Room 2014 Field Building, Central 8663.
CLEVELAND: 210 Heights Rockefeller Building, Yellowstone 2720. **DALLAS:** 30½ Highland Park Village, Justin 8-8453.
DETROIT: Room 1026 Fisher Building, Trinity 1-6363. **HOUSTON:** 6731 Harrisburg Boulevard, Wayside 3-1246.
LOS ANGELES: 2244 East 37th Street, Kimball 6384. **MILWAUKEE:** 1717 E. Kane Place, Lakeside 2838.
NEW YORK CITY: 122 East 42nd Street, Lexington 2-8260. **PHILADELPHIA:** 401 North Broad Street, Bell-Walnut 2-6997.
REDWOOD CITY, CALIF.: Broadway and National, Emerson 6-3861. **WEST SPRINGFIELD, MASS.:** 1025 Elm Street, Springfield 2-1881.
WICHITA: 340 North St. Francis Street, Wichita 2-6971.

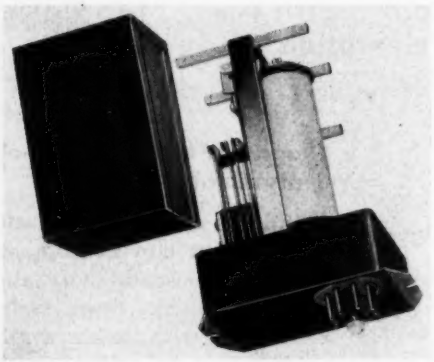
Reprints from this or other Logbook pages are available for your files. Request them from our Redwood City, California office

throw; and double-pole single and double-throw. Ratings are 10 amperes per contact pole at 6 to 230 volts a-c or d-c. Complete relay with cover measures 3¼ by 2 5/16 by 2 9/16-inches high over plugs. Manufacturer: Grayhill, 1 N. Pulaski Rd., Chicago 24.

For further information circle MD 48 on Page 257

Dust-Tight Plug-In Relay Housing

For use in dusty atmospheres, new relay cover accommodates either a-c or d-c relays. Assembly consists of relay mounted on dust-tight base, terminals being brought in through a Neoprene gasket. Steel



cover is fitted and secured to the base by means of a thumb screw. Either standard type plug or a 15-point plug can be incorporated. Manufacturer: C. P. Clare & Co., 4719 W. Sunnyside Ave., Chicago 30.

For further information circle MD 49 on Page 257

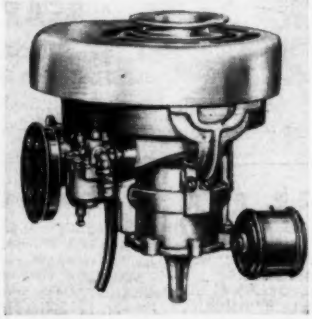
Solderless Wire Connectors

Universal Bakelite wire connector No. 3 is suitable for use with 108 different wire combinations of numbers 14, 16 and 18 wire. It will, for example, accommodate two No. 18 wires or two No. 14 and one No. 18. Manufacturer: Holub Industries, Sycamore, Ill.

For further information circle MD 50 on Page 257

Three-Horsepower Gasoline Engine

Weighing 18 pounds, the Mono-cycle engine is built of light-weight materials and embodies fewer parts than comparable engines. Because of its unusual design it is able to deliver great horsepower per pound of weight and to operate in any position. The engine uses a fuel mixture that provides lubrication, prevents carbon difficulties and assures easy starting even after flooding. Full ballbearing crankshaft is counterweighted and needle bearings are used on a steel connecting rod. Manufacturer: Sensation Engine Co., Omaha, Nebraska.



For further information circle MD 51 on Page 257

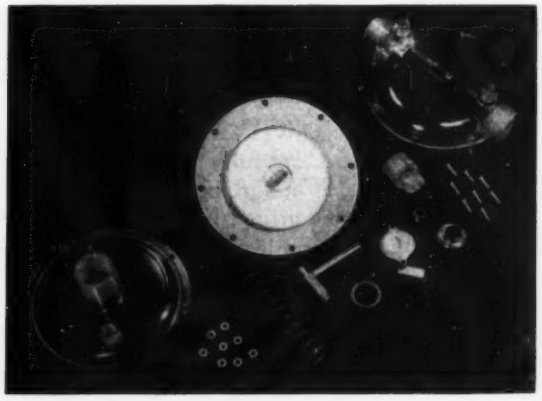
Aluminum-Spring Lockwasher

Having strength and spring tension equal to a bronze or stainless-steel lockwasher, the Diamond G spring lockwasher is designed for use with all types of light metal assemblies. The fastener has the advantage of light weight and corrosion resistance and is manufactured in all standard sizes. Manufacturer: George K. Garrett Co., 1421 Chestnut St., Philadelphia.

For further information circle MD 52 on Page 257

Plastic Test Models

Working test or scale models of machines and mechanisms are made of clear plastic, facilitating study of the operation of internal parts. Models are methyl methacrylate in any size and almost any



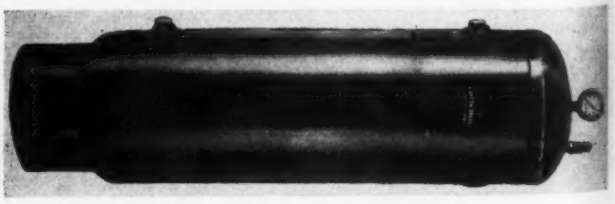
complexity of form. They are machined from block plastic to close tolerances. Manufacturer: Brown Pattern Works, 29675 Lakeland Blvd., Wickliffe, Ohio.

For further information circle MD 53 on Page 257

Air Receivers

Line of air receivers is made in sizes from 9 to 170 gallons capacity. The receivers will handle all gases and liquids under pressures up to 200 psi. They are inspected by hammer test under hydrostatic pressure as well as a double-rating pressure test and are provided with a certified code tag. Manufacturer: Dayton Rogers Mfg. Co., 2824 13th Ave., South, Minneapolis 7.

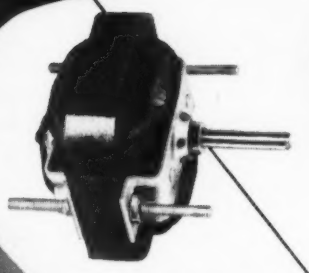
For further information circle MD 54 on Page 257

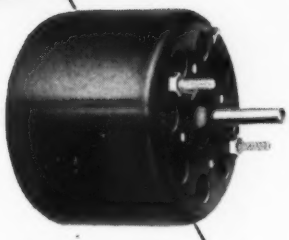


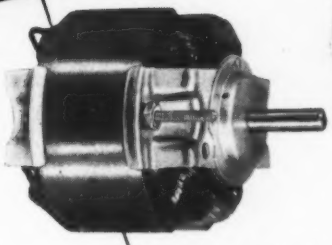
For NEW product design and sales advantages . . .
Compare YOUR motor needs with

The NEW COMPLETE FASCO LINE of FRACTIONAL H.P. MOTORS

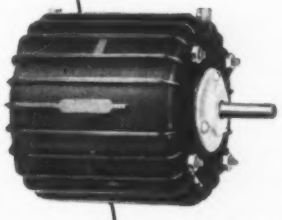
(Shaded Pole 1/500 to 1/8 H.P.)

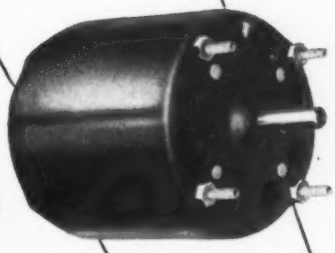

1/500 to 1/100 H.P.

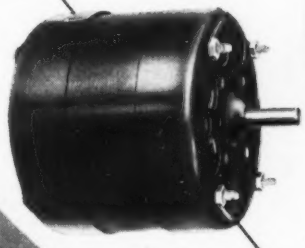

1/500 to 1/100 H.P.

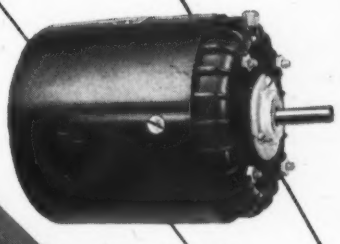

1/50 and 1/30 H.P.

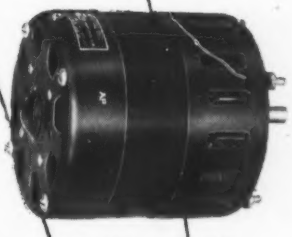
1/50 and 1/30 H.P.


1/50 to 1/25 H.P.


1/225 to 1/25 H.P.


1/20 to 1/8 H.P.


1/50 to 1/25 H.P.


1/20 to 1/8 H.P.

● Profitable competitive selling starts with successful competitive designing. You may find just the right competitive sales features you need in the new *complete* FASCO line of F.H.P. motors. And, the electrical and physical characteristics of these motors can be engineered by FASCO *experienced* know-how to adapt a *standard* motor to *your* product's *special* requirements. These FASCO quality-built motors are available in two and four pole models, at the H.P. ratings shown, rated for fan loads or power loads, for continuous or intermittent duty, with speeds from 1530 to 3075 Full Load R.P.M.

WRITE FOR NEW CATALOG— Contains full information for the engineer and designer.

A PRODUCT OF FASCO

F. A. SMITH MANUFACTURING CO., INC., 550 DAVIS ST., ROCHESTER 2, N.Y.

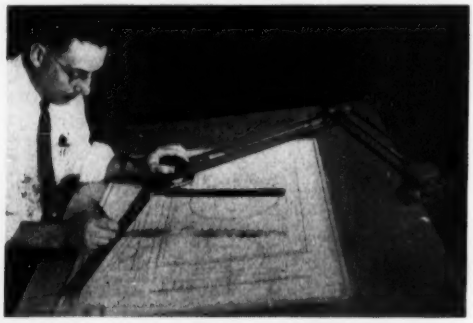
FORMERLY *Pilot* MOTORS

engineering dept equipment

In order to obtain additional information on this new equipment see Page 245

Balanced Drafting Machine

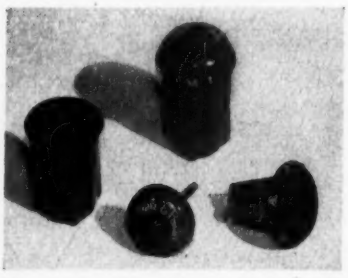
Number of new features have been included in the Equipoise drafting machines. The instruments can be used on boards inclined as much as 20 degrees without any affect on alignment. The protractor head



assembly has a redesigned base setting for locking the index point to any angle, while the relocating of the parts greatly increases visibility of the scales. Manufacturer: Charles Bruning Co., 4754 Montrose Ave., Chicago 41.

For further information circle MD 55 on Page 257

Adjustable Pencil Sharpener



Three different types of points may be cut on lead pencils using the Hold-'N-Hand Pointer pencil sharpener. Unit is of plastic construction and incorporates an adjustable indicator cap, which is positioned to allow cutting of a standard point, drafting long-lead blunt point or long-lead sharp point. Other features include replaceable blades, a shaving container and a point stop which indicates by feel when the pencil is correctly pointed. Manufacturer: Triple "E" Products Co., 4517 Olive St., St. Louis 8.

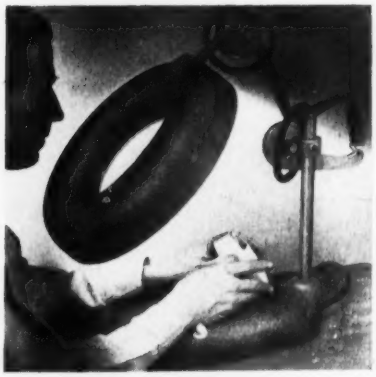
For further information circle MD 56 on Page 257

Long-Life Drawing Paper

Combining the advantages of tracing cloth and paper, Papercloth is not damaged by creases or folding, yet resists stretching, shrinking and buckling. It takes pencil and ink equally well and erases easily. The material has a marked stability under varying atmospheric conditions and has superior printing qualities. Manufacturer: Clearprint Paper Co., Dept. U, 15 First St., San Francisco.

For further information circle MD 57 on Page 257

Table-Type Magnifier



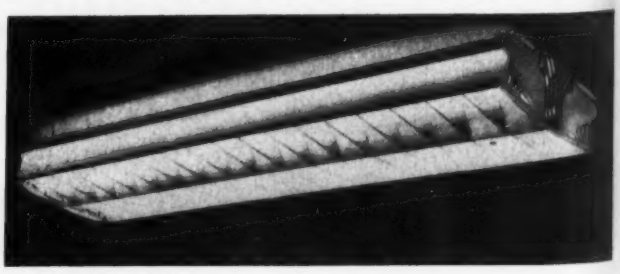
Supersite magnifier has 8-inch lens and integral lamp making it particularly useful for laboratory use. This unit is constructed with a cast-iron frame and base with a double-elbow arrangement to facilitate exact lens positioning. A 12-inch fluorescent lamp circles the lens, providing even and full illumination without shadow at every point under the lens. Floor models and other lens sizes are also available. Manufacturer: The Safety Center, 542 S. Dearborn St., Chicago 5.

For further information circle MD 58 on Page 257

Fluorescent Fixture

Ceiling-type fluorescent fixture is hinged and may be swung down for maintenance, reducing servicing time and interruption of work normally required. Unit, known as the Guth-Lite, accommodates two 40 or 100-watt lamps and achieves its side lighting without the use of glass or plastic. Manufacturer: Edwin F. Guth Co., St. Louis 3.

For further information circle MD 59 on Page 257



PUT THIS "QUICK CHANGE ARTIST" ON YOUR A-C TO D-C POWER JOBS

Manufacture d-c power right where it's needed . . . with the Westinghouse Power Pack. It's the practical way to run small d-c motors from an a-c source, where up to 4 to 1 adjustable speed control is required by field control. D-c power is made available instantly when a-c power is turned on.

The Power Pack is easy to install in any convenient, out-of-the-way location . . . overhead or right by the driven machine. Valuable floor space is saved, no foundation is required. It's small in size, light in weight, obtained by using Selenium rectifying units.

The cells are made by a new process recently developed by Westinghouse. They have superior characteristics that result in economy of operation through higher efficiency, high power factor and longer life.

Westinghouse Power Packs are available in six sizes, 1 to 15 hp. 1 to 7½-hp ratings are self-cooled, have no moving parts. Larger sizes are air-cooled.

For more information, call your nearest Westinghouse office, or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa.

J-21471

WESTINGHOUSE SELENIUM POWER PACKS MANUFACTURE D-C FROM A-C . . . ON THE SPOT

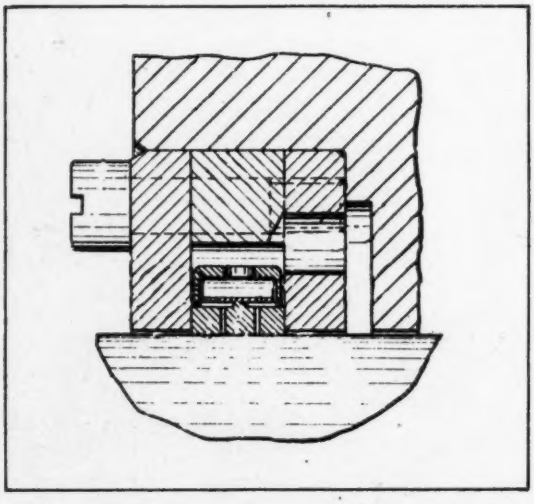
Selenium Power Pack installed close to the d-c motor it serves. Door was removed to show simplicity of construction. Only moving part is the a-c motor-driven fan for forced-cooling.

Westinghouse Selenium POWER PACKS

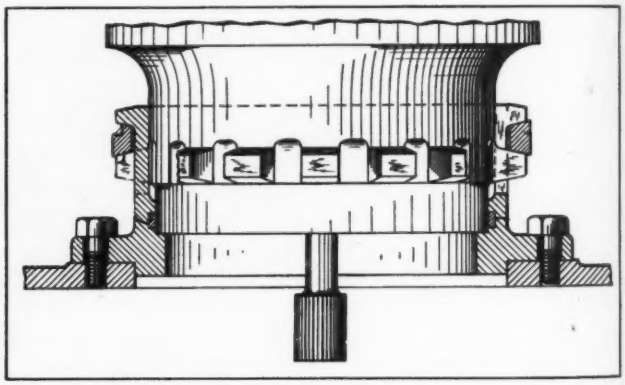
Noteworthy Patents

LUBRICATION for an unusual fuel injection pump for internal-combustion engines is provided direct from the engine pressure system without complication of external lines. Utilizing a hollow driving shaft, the pump is supplied with oil for the working mechanisms through the interior of the shaft, return being effected through a port in the pump housing which communicates with the interior of the engine. Special fuel channels for the pump are also obviated by a construction which permits the fuel to be delivered to the fuel ducts of the engine through hollow cap screws by which the pump is attached to the engine. Covered by patent 2,436,797 assigned to Deschamps Fuel Injector Corp. by D. J. Deschamps and D. C. Clarke.

HIGH SPEEDS as well as slight endplay or vibration of a rotating shaft have little effect on the life of the metal shaft seal described in patent 2,433,839. Assigned to Simplex Products Corp. by F. G. Ferguson and R. C. Thompson, the seal utilizes the centrifugal effect of speeds ranging as high as 6000 to 10,000 rpm to assist in the sealing action. Simple and compact, the unit can be readily substituted for synthetic or leather type seals. Constructed entirely of metal on the order of a piston ring, the unit is designed for sealing engagement on its inner face and rotates with the shaft while the housings are stationary. Frictional engagement of the ring on the shaft is such that the ring creeps slightly under the influence of its resilient sealing engagement with the radial housing faces. Seal is claimed to show very little tendency to heat up in service.



RAPID MOUNTING of engine accessories which require frequent overhaul, such as on aircraft, by means of a single bolt is provided by a unique mount design invented by George B. Du Bois. Assigned to the Wright Aeronautical Corp. under patent 2,439,161, the mount may be used on conventional engine accessory mounting pads. Comprising a primary adapter ring having axially extending lugged fingers, the ring can be easily bolted to an engine in the ordinary manner. The engine accessory, provided with mating lug projections, can be readily slid into place to allow secure fastening by means of a split wedge ring having but a single lock bolt.



LINEAR MOTION is translated into rotary motion without trigonometric error in a new absolute pressure gauge covered in patent 2,437,371. Action of the gauge bellows member is transmitted to the ball-bearing mounted rotary shaft through three balls to a triple-lead spiral thread with a minimum of friction losses. Motion is transmitted to the indicator hand from the hermetically sealed container by magnetic means. Patent is assigned to Stewart-Warner Corp. by Arthur C. Allen.

BURKE *Announces . . .*

SERIES "D" SQUIRREL CAGE INDUCTION MOTORS

LARGER THAN NEMA FRAME SIZE!

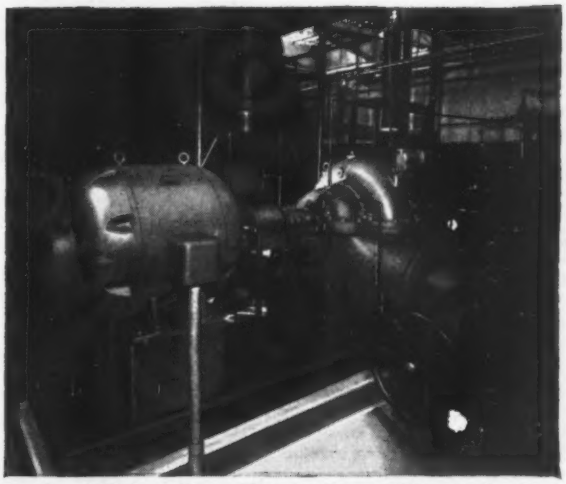
TO 500 H.P.

Same general design in larger than NEMA FRAME SIZES TO 500 HP. (500 hp. illustrated)

(Largest)
NEMA FRAME No. 505

(Smallest)
NEMA FRAME No. 203

EARLY in 1947 Burke introduced its new Series "D" drip-proof design for open type motors. These are available in NEMA Standard Frames 203 thru 505. This range is shown above in the two smaller motors. Now Burke extends this streamlined design with its generous proportions, in frames larger than NEMA Standard—up to 500 hp. for all standard speeds to 3600 r. p. m. Consult with Burke for data on these high grade uniformly designed induction motors in sizes from 1/4 to 500 hp.



Burke 125 hp. Drip Proof, Type NAD, Induction Motor, driving a DeLaval 9750 g. p. m. Centrifugal Pump. Frame 681, 720 r. p. m., 2300 Volts, 3 Phase, 60 Cycle, Sleeve Bearings.

BURKE ELECTRIC COMPANY 1988 W. 12th ST. ERIE, PA.

UNIVERSAL MOTORS 1/30th to 1½ HP | SINGLE PHASE MOTORS to ½ HP | INDUCTION MOTORS 1 to 1500 HP | SYNCHRONOUS MOTORS to 1500 HP GEN. to 1000 Kw. | TERMINAL BLOCKS 10 TYPES | D.C. MOTORS to 1500 HP GEN. to 1000 Kw. | M-G SETS to 1000 Kw. | HIGH CYCLE M-G SETS— 7 STD. SIZES

Silicone News

DC SILICONES

DC 44 Silicone Grease for reliable permanent lubrication

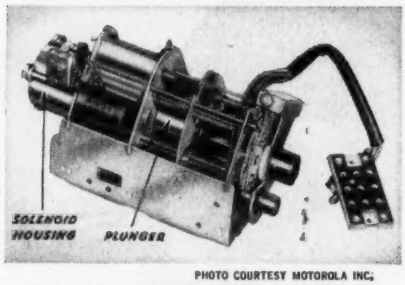


PHOTO COURTESY MOTOROLA INC.

DC 44 Silicone Grease permanently lubricates the plunger-solenoid contact surfaces in this Motorola Auto Radio push-button tuner.

Actual performance is the only true measure of a lubricant's quality. That is why more and more manufacturers are specifying Dow Corning Silicone Greases for their lubrication problems. Their tests show that longer lubrication life, greater oxidation resistance, elimination of gumming, and indifference to temperature extremes are all characteristic of the silicone greases.

Motorola Inc. of Chicago had a lubrication problem in their auto radio push-button tuner. The tuning is accomplished by a solenoid and plunger with a dash-pot action between the two for smoother operation. A thin film of the lubricant selected had to be permanent and maintain its consistency over the operating temperature range from −20° to 160°F. to give the dash-pot action.

Their engineers tested many lubricants but the only one to allow satisfactory operation and still lubricate after 75,000 cycles was DC 44 Silicone Grease. It maintains the right consistency to give smooth action and permanent lubrication. Even in thin films this silicone grease does not run out or form gum.

We recommend DC 44 Silicone Grease for permanently lubricated anti-friction bearings, and for high temperature applications up to 350°F. DC 41 Silicone Grease is recommended for temperatures up to 450°F. DC 33 Silicone Grease is both a low and a high temperature grease and is recommended for use from −95° to 300°F.

If you want permanent lubrication or have high temperature or low temperature problems it will pay you to investigate Dow Corning Silicone lubricants. Write for data sheet B 7-5 or call our nearest sales office.

DOW CORNING CORPORATION
MIDLAND, MICHIGAN
New York • Chicago • Cleveland • Los Angeles
Dallas • Atlanta
In Canada: Fiberglas Canada, Ltd., Toronto
In England: Albright and Wilson, Ltd., London

Dow Corning
FIRST IN SILICONES

Dow Corning Silicone Products include

FLUIDS
Damping
Hydraulic
Dielectric
Waterproofing
Lubricating
Diffusion Pump
Mold Release

GREASES
High Temperature
Low Temperature
Valve Lubricants
Stopcock
High Vacuum

COMPOUNDS
Ignition Sealing
Antifoam A

RESINS
Electrical Insulating
Laminating
Protective Coatings

SILASTIC*
Molding
Extruding
Coating
Laminating

*Trade Mark
Dow Corning
Corporation

Design Is Primary Topic

(*Continued from Page* 105)

drill. As flash is left in through-holes that are cored and generally must be removed subsequently by a drill or punch, it is often cheaper to drill or pierce than to core such a hole.

Where a hole or recess is needed and can be cored, there is not only a saving in metal but the metal saved does not have to be cut away and remelted. Moreover, by avoiding concentrations of metal, especially at bosses, sections can be made more nearly uniform in thickness. This means faster cooling in the die and sounder castings, for porosity is prone to occur where sections are thicker locally than those of adjacent sections.

Induction Heating Possibilities

By H. B. Osborn Jr.
Technical Director, Tocco Div.
The Ohio Crankshaft Co.
Cleveland

BY designing a part in such a manner that induction heating can be used, savings may be accomplished which more than justify the installation of the induction heating machine. A good example is a track-roller assembly used by tractor manufacturers. Prior to the adoption of induction heating this roller was made in various ways. A rather expensive casting had proved to be satisfactory from the standpoint of service, but the cost was prohibitive. Using forging the cost of the forging plus subsequent machining also was objectionable. Another alternative, used for experimental purposes, was that of machining the part out of a large-diameter bar. This necessitated a costly removal and waste of material and a final product which was very expensive.

Performing a Dual Task

In an attempt to economize, experiments were conducted whereby the roller was made in three parts, the assembly of the flange to the hub being accomplished by welding. The final design, which is now standard practice, involves the use of induction heating for performing a dual task. The roller hub is inserted in an induction hardening machine with the two rollers on either side with bores properly lined up with the hub ends. The two rollers are rotated through a specially designed high frequency inductor and the surfaces of the rollers, which must be hardened for service, are brought up to hardening temperature.

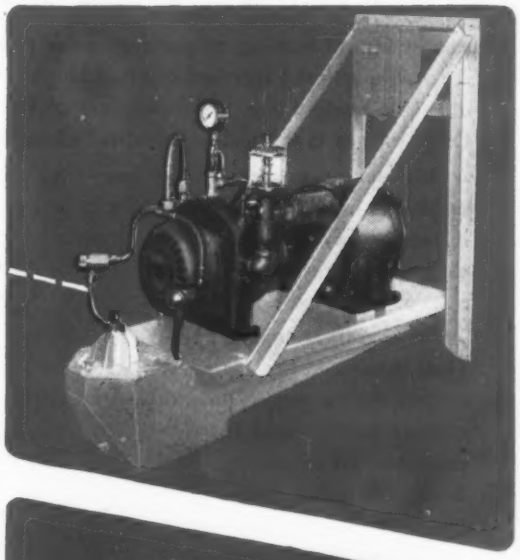
At this instant, the surface of the rollers is at a temperature which will permit hardening but enough heat has drifted to the bore of the roller to expand it slightly. Hydraulic rams drive the roller over the hub and the quench is turned on automatically. This produces surface hardening of the roller and adjacent flanges, and shrink fits the roller to the hub simultaneously. The shrink fitted joint is immeasurably stronger than a welded joint, due primarily to large area contact under pressure. This rather

THEY MADE *AIR* DO THE WORK—

THROUGH *Visioneering* *

. . . ON A HUMIDITY CONTROL UNIT

Here's Visioneering applied by designers of a Humidity Control Unit for bakery proof-rooms. To atomize water through spray head, a Gast Rotary Compressor, as original equipment, supplies "pulseless" air pressure. No tank needed. Unit keeps air in room at 98% humidity. Direct drive, ¾ H.P. Rating is 8½ C.F.M., pressure to 25 lbs. Compressor has automatic lubricator with visible oil supply, intake filter and cooling fans.



. . . ON A FILTER FOR EDIBLE FAT

On a totally different application, air does the work on another manufacturer's Portable Filter. With pressure to 25 lbs., a Gast Rotary Compressor forces fat through filter medium. This reclaims valuable fat for re-use — effecting big savings. Gast Compressor and motor are integral — only 7" x 12" overall. Gast's packaged design also speeds manufacturer's final assembly. Rating: 1½ C.F.M. with ¼ H.P.

Both USE GAST ROTARY AIR COMPRESSORS

Notice that the two machines described are *totally unlike*, although both serve in the processing of food. Yet their designers *visioneered* them as *better* products — with Gast Rotary Compressors as original equipment.

Have *you* a design problem you can solve with AIR? Can you get improved product performance — reduced bulk — increased safety — or better control — through *visioneering*? Many designers have — by specifying Gast *Rotary Design* Compressors, Vacuum Pumps or Explosion-proof Air Motors as *original equipment*. If *air* pressure, vacuum or power can be applied on your products, we'll be glad to co-operate with engineering help. *For details, write Gast, describing your problem.*

** Broad vision plus engineering skill.*

GAST ROTARY AIR MOTORS COMPRESSORS VACUUM PUMPS

"Air may be your answer!"

AIR COMPRESSORS — to 30 lbs.
VACUUM PUMPS — to 28 in.
AIR MOTORS — to 1 H.P.

GAST MANUFACTURING CORP.
107 Hinkley Street, Benton Harbor, Michigan

WRITE TODAY! Request your copy of this IDEA-CATALOG.

TIME as a factor of CONTROL in Industry

THERMEX opens up new opportunities in Plastics Molding . . . TIMED by CRAMER

Almost instant heating of preforms prior to molding is possible with the Thermex Red Head high frequency dielectric heating unit, a development of The Girdler Corp. for use in the molded plastics industry.

This device produces high frequency heat that originates *in* the material instead of being *applied to* it, resulting in a more uniform, stronger product . . . as well as increased production, simplified operations . . . reduced time and unit costs.

The Thermex unit is equipped with a Cramer Running Time Meter and two type TEC Time Delay Relays that control the heating cycle with two distinctly different characteristics and in any selected sequence. Another instance where accurate control, dependable performance are assured by Cramer Timing.

TIME DELAY RELAY

RUNNING TIME METER

A WIDELY USED CRAMER DEVICE . . . THE SYNCHRONOUS MOTOR

Precision built, this compact, dependable permanent magnet type motor is the ideal power plant for time control instruments requiring constant speed at a given frequency. For complete information, write for Bulletin 10A.

IF THE PERFORMANCE OF YOUR PRODUCT DEPENDS ON PRECISION TIMING, CONSULT . . .

Cramer

THE R. W. CRAMER COMPANY, INC.

Box 14, Centerbrook, Conn.

6CR48

novel use of induction heating made possible the manufacture of a part which could not be produced, quality-wise or as cheaply, in any other manner.

Designing for Induction Hardening

By J. T. Temin

Tocco Div.
The Ohio Crankshaft Co.
Cleveland

FORMERLY, the production engineer had to adapt the technique of high frequency induction hardening to the manufacturer's part. Now, however, the induction heating process has progressed to the point where the design engineer is requested to design the part so that induction heating methods can be used to obtain the hardening requirements.

Stationary heating for hardening is the most common form of heating, and parts must be designed with finished locating areas to permit exact positioning. If a variety of parts, similar in dimensions, are to be hardened, considerable savings in tooling cost can be obtained by designing standard locating areas. Stationary positioning is adapted to heating short length and eccentric and miscellaneous contours.

To avoid the "fish-tail" effect occurring at the split section of the inductor block, the part to be hardened should be rotated during the heating operation. Consequently, if at all possible, the parts should be symmetrically designed to permit rotation in the inductor. There are many stationary fixtures whose designs are limited only by the ingenuity of the designer. Where the parts are long, yet require selective hardening, "V" fixtures can be used to advantage. If the design calls for a massive part to be located, the "V" supports can be positioned on dollies. The entire dolly assembly is then rolled into position locating the area to be heated in the inductor.

Cylindrical bars, rods, splines, pins and shafts of various diameters and lengths are very well adapted to induction hardening using the progressive heating method. A practical rule to follow is that if the length exceeds $2\frac{1}{2}$ in. it is desirable to harden the section progressively.

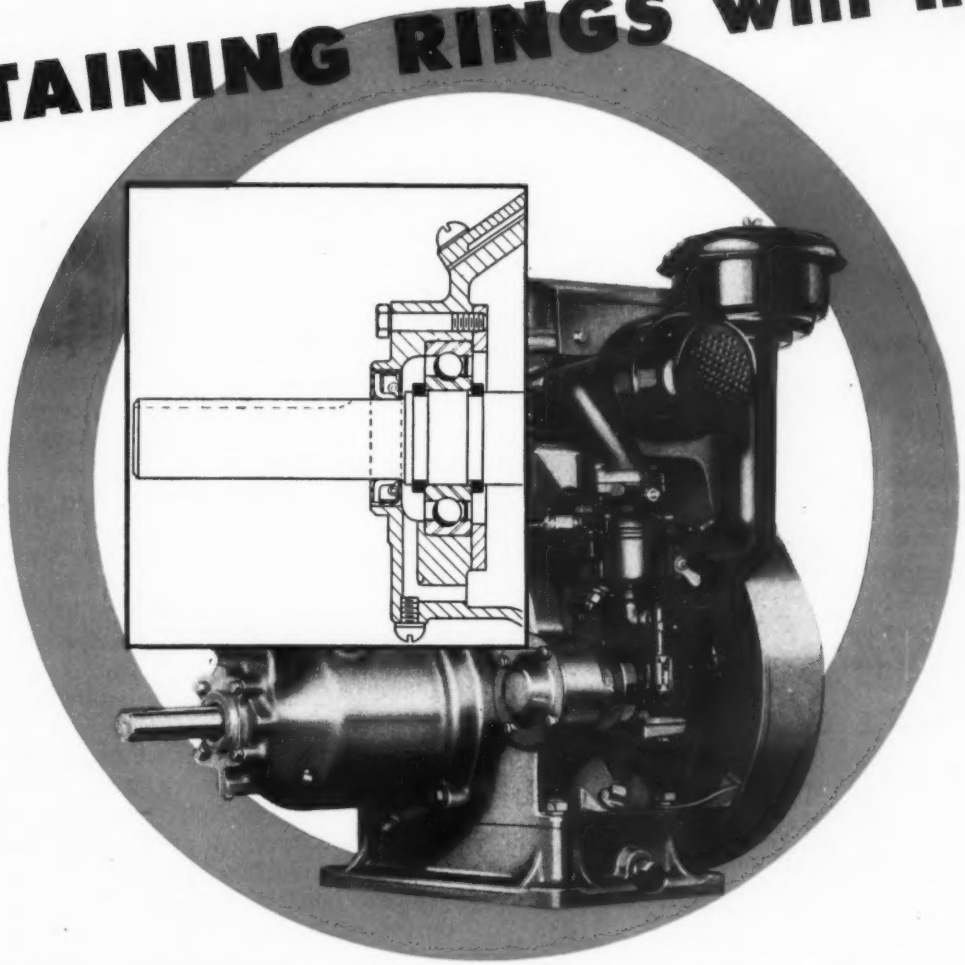
Obstructions Should be Avoided

In designing parts to be hardened by induction heating and using the progressive type fixtures, care must be exercised that no protruding areas interfere with the inductor as the part passes through the block or as the block scans the part. Should such obstructions occur in the design, the inductor must be increased in diameter for clearance which causes a loosely coupled circuit resulting in an inefficient process. An alternative step would be to use a split type inductor. In many cases, however, production requirements may not permit the loss of time in opening and clamping the inductor. Metallurgical requirements may also call for a hardened surface up to the shoulder of the protruding area, but because of this protrusion the quench water will not pass over the heated area and consequently the result will be a nonhardened surface.

Although the technique has been developed for satisfactorily hardening irregular surfaces such as slots,

SAVE wherever you can!

RETAINING RINGS will help



These inexpensive, efficient artificial shoulders save metal and money on Wisconsin air cooled heavy duty engines.

And in addition to saving money and metal, retaining rings save many costly hours in assembly time. Instead of the former wasteful practice of cutting down large shafts, you can redesign to groove smaller shafts and use these high grade steel rings. In your housings, too, rings will save money and improve your products, your machines and your profits.

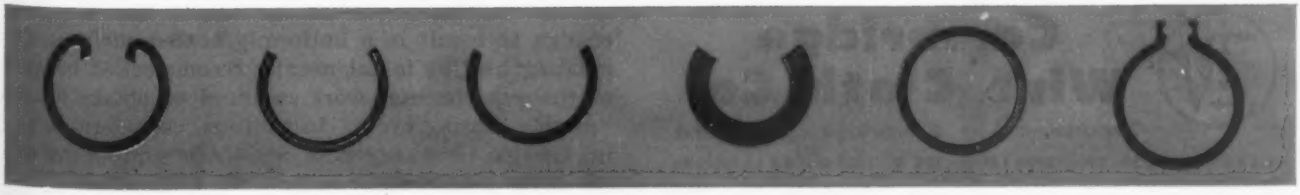
Every product—metal, wooden or plastic—and every machine should be examined now to see where shoulders and collars can be redesigned to effect great savings by the use of steel retaining rings.

Let us show you how they can do an efficient job for you on your shafts or in your housings.

Write today for booklets on many types of National Retaining Rings.

THE NATIONAL LOCK WASHER CO.

NEWARK 5, N. J. **MILWAUKEE 2, WISCONSIN**



Free drainage and circulation now possible for CONTINUOUS WASH PROCESSES

Wide open mesh permits washing from above or below, gives free drainage and heat flow

with NEW

Cambridge Twistex

WOVEN WIRE CONVEYOR BELT

Cambridge TWISTEX—a revolutionary, new woven wire conveyor belt—is specially constructed to combine maximum strength with maximum open area. Up to 87% open mesh! This *straight-line mesh* is ideally suited to any mass washing, drying, heating or cooling operation. The wash stream can be directed from above or below the work and the mesh openings provide free circulation of solutions or air.

Combine these factors with tough, all-metal construction and you have a conveyor belt that speeds production, requires little maintenance or control. Woven from any metal or alloy, for frictional drive or sprocket drive without chains.

Write today for full information on Cambridge TWISTEX woven wire conveyor belts. See for yourself how it can speed your processing operations by combining movement with processing. New Cambridge TWISTEX is made only by—

Cambridge Wire Cloth Co.

Department A • Cambridge 8, Maryland

SALES OFFICES IN: BOSTON • NEW YORK • BALTIMORE
PITTSBURGH • DETROIT • CHICAGO • SAN FRANCISCO • ST. LOUIS

threads, splines, grooves etc., using induction heating methods, caution should be exercised in designs which combine such areas with straight surface hardening. Unless inductors are specifically designed to harden irregular surfaces, for example a slot or a splined area, difficulties may be encountered not only from the overheating as previously mentioned, but also from the erratic splashing caused by the quenching water on the irregular surface.

Rotating the Part Lessens Distortion

Tests on many parts indicate that distortion can be minimized by rotating the part during the heating and quenching operation. If, however, the surface to be hardened contains an obstruction or irregular surface, as already mentioned, rotation may have to be eliminated because of the uncontrolled splashing.

Continuous fixtures consist, among others, of conveyors, rotating tables, pushers and indexing and cam control mechanisms. If parts can be designed for hopper feeding and chute spills, manual loading can be eliminated, making the entire process completely automatic.

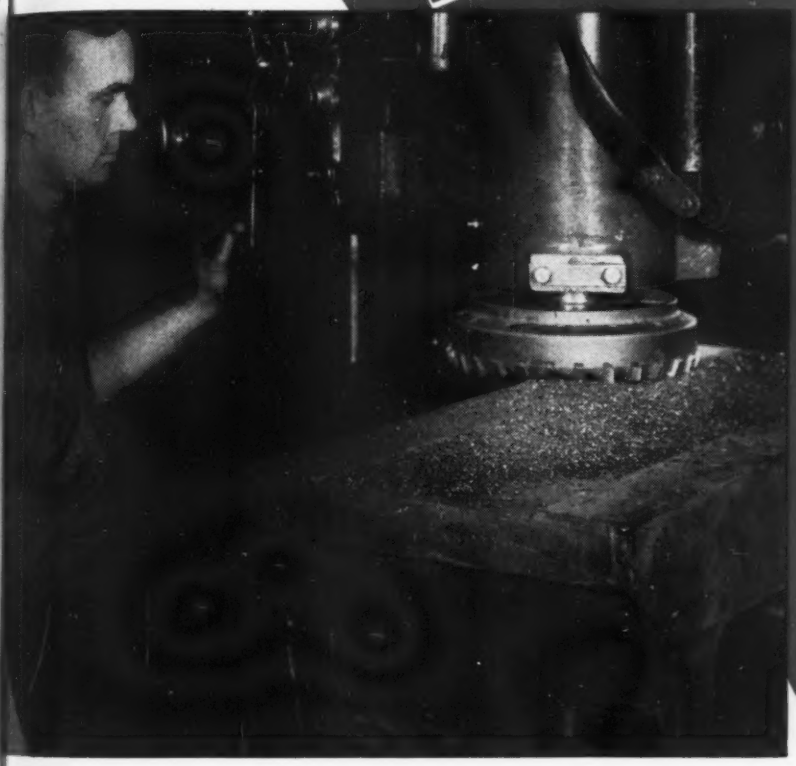
Whichever method is used, the designer must exercise caution so that the part can be properly positioned and located during heating. Tooling is often the greatest burden in a manufacturing process; consequently, in designing a part, consideration should be given to the fact that continuous loading and unloading will cause locators to wear. Locating areas should provide sufficient length and clearance, so that spring or tension devices used on fixtures can be insulated from any heat that may possibly destroy their elasticity. At all times it must be kept in mind that induction heating is a direct result of the magnetic lines of force or flux produced by the inductor, and that any metal passing through the magnetic field, be it the part to be processed, or be it the fixture, will be heated. Although the fixture may be designed to resist high temperature, close coupling of metallic parts of the fixture to the inductor may absorb power, and as a result destroy the heating cycle and cause the part to be underheated.

Oscillating Heating not Desirable

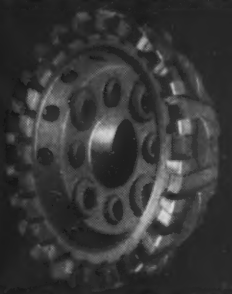
Parts designed with flat surfaces and valleys to be hardened may require an oscillating heating method since it may not be possible to obtain a uniform temperature over a wide surface by the methods described in the foregoing. Wall thickness variations, drilled holes, grooves, etc., may cause areas to overheat while adjacent areas have not reached the critical temperature; consequently an inductor is passed over the surface of the part at a predetermined frequency until the heat has soaked into the part long enough to result in a uniformly heated surface. Oscillating heating is not usually recommended because of the experimental work required to obtain an acceptable heating cycle. In addition, considerable setup time is necessary with automatic equipment and relatively long heating cycles.

Continental ENGINEERING IN CUTTING TOOLS Makes the Big Difference!

Below: Rough milling a casting with a Continental Inside Cone Face Milling Cutter. This type of cutter is especially economical in rough milling because the principal direction of blade adjustment is toward the periphery where major wear occurs.



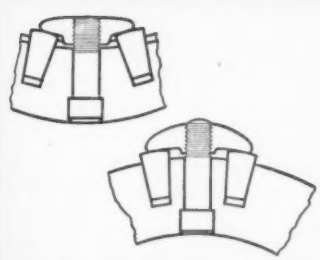
Above: Continental Inside Cone Face Milling Cutter for roughing and general purpose work.



Above: Continental Outside Cone Face Milling Cutter for finishing and general purpose work.

CONTINENTAL **cutting tools made by Ex-Cell-O** ***(from standard counterbores and face milling cutters to all types of broaches and special carbide-tipped tools of intricate design)*** **are now used almost universally throughout the metal-working industry in shops both large and small. This exceptionally wide experience in designing and manufacturing cutting tools is one of the reasons why every Continental cutting tool leaving the Ex-Cell-O plant—no matter what the cutting material or the purpose of the specific tool may be—faithfully represents the high Ex-Cell-O standard . . .** ***assurance of correctness in design, thoroughness in manufacture, and the most practicable of accuracy and production in operation....*** **Prompt delivery can be made of Continental standard and special tools—call in your Continental representative today, or write to Continental in Detroit.**

CONTINENTAL TOOL WORKS
CTW
EX-CELL-O CORPORATION



Above: These illustrations show how blades are locked in Continental Face Milling Cutters—inside cone type at the left and outside cone type at the right. One clamp locks two blades securely in place — no wedges, pins or set screws are used — no special tools are required.

—18

CONTINENTAL TOOL WORKS

DIVISION OF EX-CELL-O CORPORATION

DETROIT 32, MICHIGAN

There's Food for Thought for You in —

The Case of the Ritzy Restaurant

Purchasing Agent: *"I thought this was a first class place to eat. Just look — paper napkins!"*

Chief Draftsman: *"You should talk! Over at the plant you expect my department to produce useful drawings on perishable tracing paper instead of permanent Arkwright Tracing Cloth!"*

As vital as each expertly drawn plan, is the material which receives, reproduces and preserves it. For this important purpose, the matted fibers of paper cannot compare with the selected, uniform, new cotton fibers woven and bonded into Arkwright Tracing Cloth! Use Arkwright, even for preliminary or one-job drawings that may be urgently needed for future use or reference. That's the safer, thriftier way!

Prove to yourself the extra worth and work ability of Arkwright for all drawings. Send for generous working samples. Arkwright is sold by leading drawing material dealers everywhere. Arkwright Finishing Co., Providence, R. I.

The Big Six Reasons Why Arkwright Tracing Cloths Excel

1. Erasures re-ink without feathering.
2. Prints are always sharp and clean.
3. Tracings never discolor or go brittle.
4. No surface oils, soaps or waxes to dry out.
5. No pinholes or thick threads.
6. Mechanical processing creates permanent transparency.

ARKWRIGHT

TRACING CLOTHS

AMERICA'S STANDARD FOR OVER 25 YEARS

Gear Noise

(*Concluded from Page* 137)

The basic design of the new Acoustical Laboratory is such that the following test conditions essential for basic acoustical investigations can be met:

(a) Machines under test can be isolated acoustically from connected machinery. This is done by placing the machinery under test, and the connected machinery, in separate rooms whose boundaries provide a high sound transmission loss. Shafting connecting the machinery penetrates the boundaries of the rooms through soundproof seals.

(b) Ground-borne noise and vibration are suppressed by isolation of massive machinery test beds from the surrounding building structures and the soil by isolation trenches.

(c) Ambient air-borne noise is attenuated approximately 45 db by essentially monolithic heavy concrete walls.

(d) Reverberation and standing-wave effects in the test rooms are practically eliminated by anechoic sound-absorbing linings having a wide range flat absorption characteristic which minimizes the need for spectrum corrections.

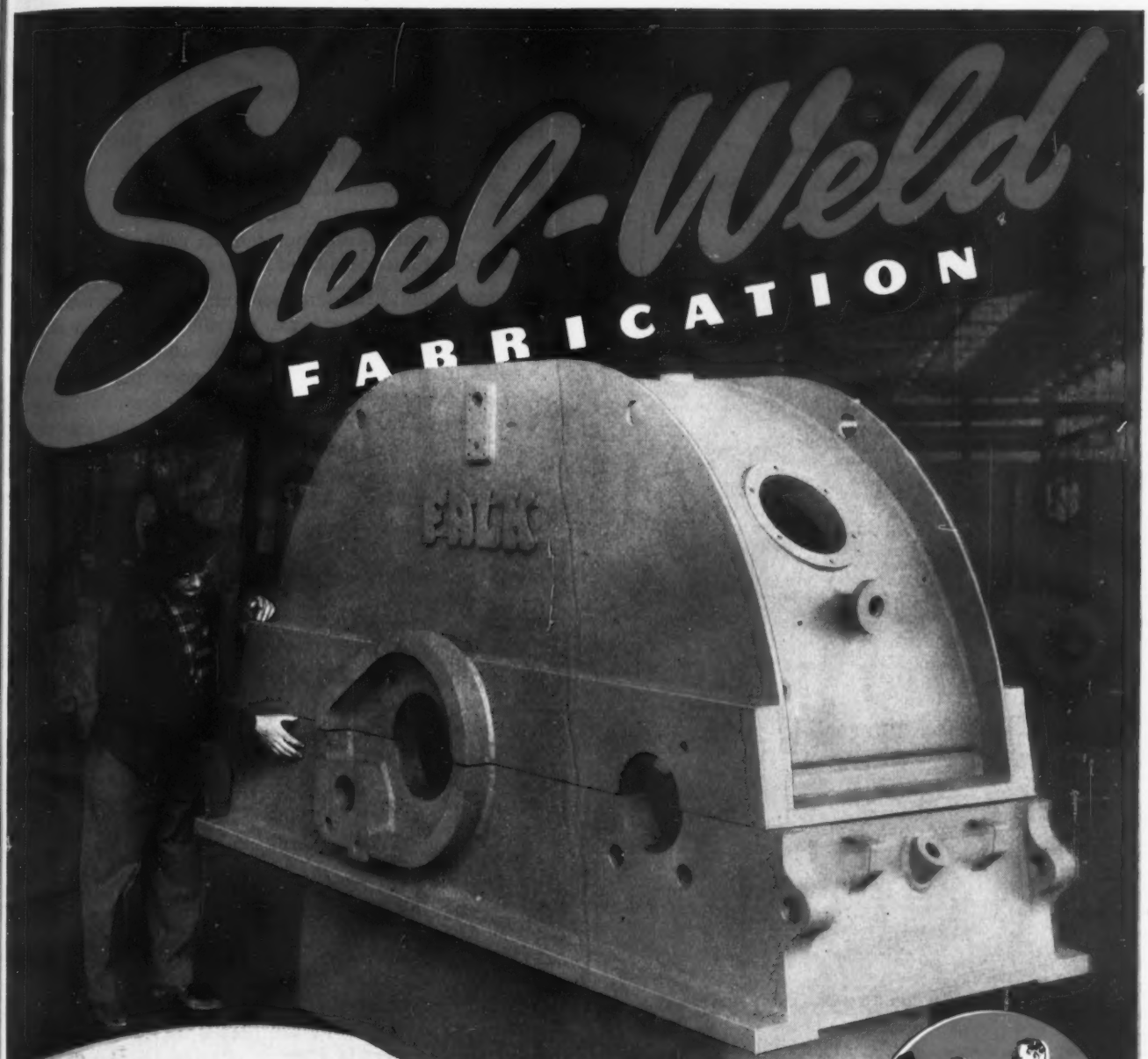
(e) Piping systems are isolated from the machines they serve by nonmetallic connectors, except in cases where excessive temperatures render the use of such connectors impracticable, as in the case of high-temperature steam piping.

The laboratory will be equipped for performing noise tests on propulsion and auxiliary machinery and acoustical accessories. The principal features of the laboratory are three large anechoic machinery test rooms, an underwater sound tank, an anechoic transducer calibration room, a service equipment room, offices, instrument rooms and a large ventilation fan room. In addition, a separate power house is provided for furnishing large amounts of d-c power necessary for energizing large electric driving motors. Each of the anechoic test rooms is large enough to accommodate either individual machines or the assembled machinery plants of ships.

CONCLUSION: The present trend of Naval machinery development appears to insure an important role for propulsion reduction gears. Through the joint efforts of the American gear industry and the Navy, current and prospective gear developments promise to revolutionize prevailing concepts of gear design. High efficiencies and greatly increased load capacities seem to be assured.

To make these newly developed gears usable, especially on submarines and antisubmarine ships, stringent noise requirements will be an imperative military necessity. It is recognized that the reduction of gear noise to acceptable levels is an extremely difficult technical problem whose solution will require the cooperative efforts of the gear industry and the Navy. The acoustical facilities being provided by the Navy are a token of recognition of its obligation to handle its share of the problem. It is hoped that the gear industry will feel welcome to avail itself of any help which these facilities can provide.

Steel-Weld FABRICATION

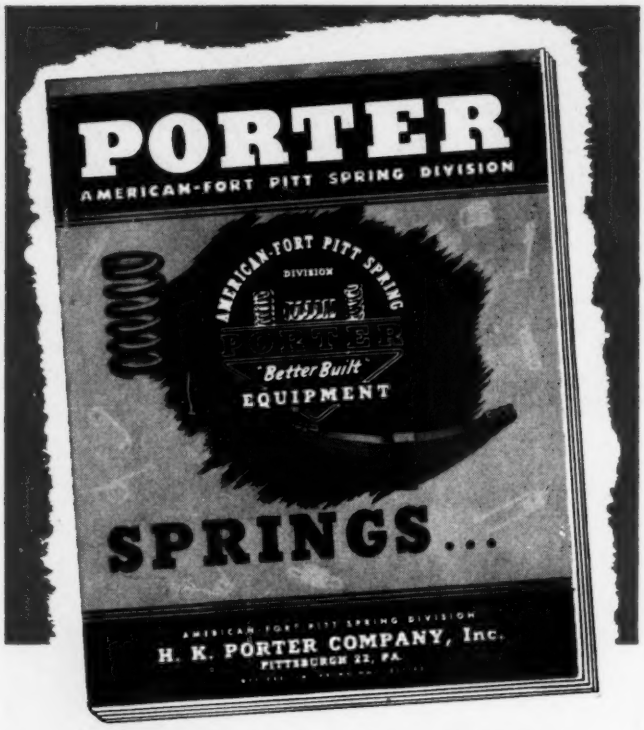


Here is another sample of Mahon workmanship in the production of weldments for manufacturers of machines and other units of heavy equipment. In the Mahon organization you have a source for tailor-made weldments which offers every modern facility for economical production, processing, and complete machining, regardless of size, weight or shape. This, backed up by a staff of design engineering specialists and highly skilled craftsmen, is your assurance of a better, smoother appearing job embodying every advantage of Steel-Weld Fabrication.

THE R. C. MAHON COMPANY
Detroit 11, Michigan

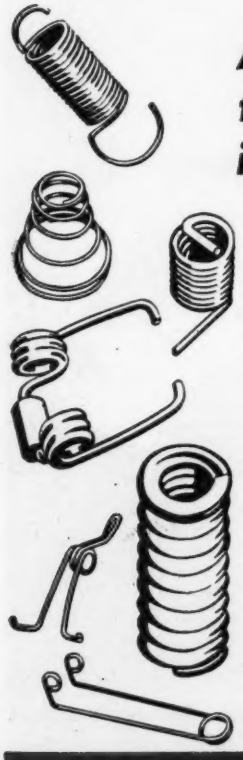
Engineers and Fabricators of Welded Steel Machine Bases and Frames, and Many Other Welded Steel Products

MAHON



HOW TO SPECIFY

SPRINGS



A short cut to product improvement

If you are designing or making a product requiring a spring in its assembly, you will want this book—a 28-page handbook of engineering data on springs—28 pages of formulas, graphs, charts, tables and drawings. This book will tell you all you need to know about specifying springs of any type from light wire to heavy elliptic. And it's yours for the asking. Write for your copy today.

American-Fort Pitt Spring Division

H. K. PORTER COMPANY, Inc.

PITTSBURGH 22, PENNSYLVANIA

Extrusion of Metals

(*Concluded from Page* 114)

5000 psi. A minimum standard for the lead end, which would be the softest condition, may be considered as corresponding to existing ASTM standard specifications for rod. Cold reductions can be used to improve surface finish but seldom achieve more than a superficial hardness improvement.

TOLERANCES: Standard commercial tolerances held in the general production of extruded shapes is shown in TABLE II. These tolerances are generally close enough to permit use of as-extruded parts in most routine assemblies. In the event closer tolerances are required on a specific dimension such can often be held. On payment of small extras, mills will usually accept tolerances down to one-half the commercial.

With flat surfaces the allowable deviation is usually taken as 0.004-inch per inch of width with 0.004-inch deviation from the flat as a minimum. Allowable deviation from a specified contour is plus or minus 0.006-inch for curved surfaces with chords up through 1.499 inches; 0.012-inch for 1.500 through 2.999 inches; 0.020-inch for 3.000 through 4.999 inches; and 0.030-inch for chords 5.000 inches and up.

Angular tolerance is 2 degrees, plus or minus, where thickness of the thinnest leg is under 0.188-inch, and 1½ degrees for 0.188-inch and over.

Tolerances on radii are: Plus 1/64-inch for sharp corners or fillets; plus or minus 1/64-inch for any radius up through 0.187-inch; and plus or minus 10 per cent for radii of 0.188-inch and larger.

Economy Affected by Surface Requirements

Wherever possible, for economy, surface finish as extruded should be acceptable on parts. Price penalties and restriction of suppliers may result if unnecessary requirements are placed on surface quality.

Surface quality is greatly affected by the extrudability of the material, billet heat, and speed of extrusion. Handling and straightening are rough on surface finish. Drawing reductions are usually light and do not remove all the visible scratches which may arise from heat checks and die cracks at elevated temperatures. For best surface quality on copper extrusions, two cold draws are necessary to remove normal defects due to the pressure and high temperatures needed. Surfaces sometimes can be sanded, polished or buffed to improve surface finish but as a rule such operations are not too well suited for handling in the mill and in any but large-quantity runs would be uneconomical.

Collaboration of the following organizations in the preparation of this article is acknowledged with much appreciation:

Aluminum Co. of America (*Figs.* 14 and 16) ..... Pittsburgh, Pa.
American Brass Co. (*Fig.* 4) ..... Waterbury, Conn.
Harvey Machine Co., Inc. ..... Torrance, Los Angeles, Calif.
Magnesium Div., Dow Chemical Co. (*Fig.* 3) ..... Midland, Mich.
Revere Copper & Brass Inc. (*Figs.* 2 and 5 through 13) ..... New York, N. Y.
Reynolds Metals Co. (*Figs.* 1 and 15) .... Louisville, Ky.

DEFINITE TIME ACCELERATION!

REDUCED VOLTAGE STARTING!

EDGEWOUND ACCELERATING RESISTORS!

CLARK Bulletin 6080 A.C. MAGNETIC STARTERS

PRIMARY RESISTOR TYPE FOR SQUIRREL CAGE MOTORS

MOTOR OVERLOAD PROTECTION!

COPPER-TO-COPPER CONTACTS!

SELF-CLEANING CONTACTS!

ARCS QUICKLY EXTINGUISHED BY BLOWOUTS!

SWING-OUT CABINET FOR EASE OF INSPECTION!

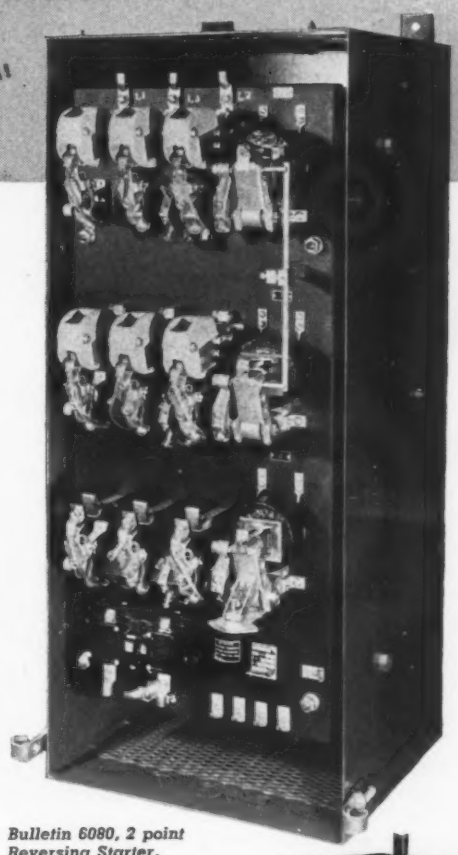
Where mechanical limitations of drives require reduced starting torque or where Power Companies restrict starting voltage,—use CLARK Bulletin 6080 Magnetic Starters for A.C. squirrel cage induction motors.

Reversing and Non-Reversing

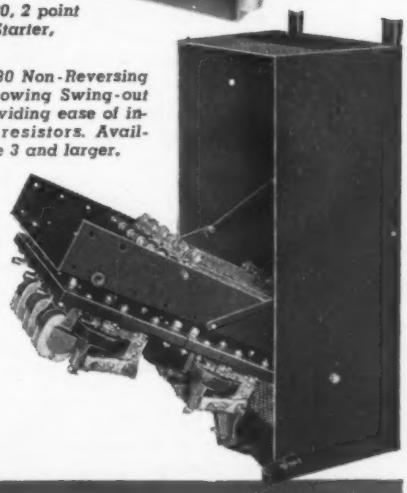
Starting voltage is reduced by connecting motors to line through a resistor, which is short circuited after a definite adjustable time to allow application of full voltage. Unit consists of line contactor for making and breaking power circuit (two for reversing types), a timed accelerating contactor for short circuiting starting resistors, a class 116 edgewound resistor, and a duplex overload relay. High-inertia type starters for machines with high "fly-wheel" effect, and accelerating time of more than 5 seconds, use class 156 edgewound resistors and long-time-delay accelerating relay.

Bulletin 6080 Primary Resistor Starters are available in reversing and non-reversing types, sizes 2 through 7.

Especially attractive for machine tool applications —either reversible or non-reversible.



Bulletin 6080, 2 point Reversing Starter, Open view



Bulletin 6080 Non-Reversing Starter, showing Swing-out feature providing ease of inspection of resistors. Available on size 3 and larger.

EVERYTHING UNDER CONTROL

THE CLARK CONTROLLER CO.

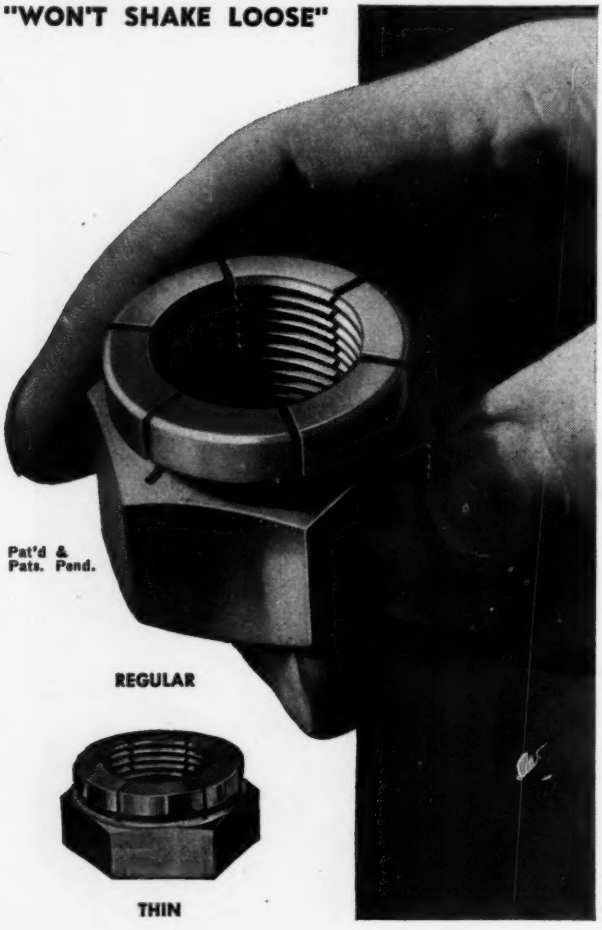
1146 EAST 152nd STREET, CLEVELAND 10, OHIO

ASK FOR SAMPLES

FLEXLOC ONE-PIECE

SELF-LOCKING NUTS

"WON'T SHAKE LOOSE"



The one-piece, all-metal, all-active thread, "Flexloc" packs maximum usefulness in minimum space by combining, as it does, a stop, a lock and a plain nut all in one.

Every thread—including the locking threads—takes its share of the load. "Flexloc" accommodates itself to a wide range of thread tolerances . . . can be used over and over again without losing much of its locking torque . . . is not affected by temperatures likely to be met within the field of Mechanical Engineering . . . and being a "stop" nut, it stays locked in any position on the threaded member. The "Flexloc" is processed to have an exceptionally uniform torque.

The *Thin* "Flexloc" has become very popular because its *tensile* is so high and the space it occupies so small.

Sizes from #6 to 2" in diameter—in "regular" and "thin" types—in NC and NF thread series. Write for "Flexloc" Catalog.

OVER 45 YEARS IN BUSINESS

STANDARD PRESSED STEEL CO.

JENKINTOWN, PA. Box 102

Branches: CHICAGO • DETROIT • INDIANAPOLIS
ST. LOUIS • SAN FRANCISCO

BUSINESS AND SALES BRIEFS

LEONARD P. FULLER and Richard H. Krueger have been appointed California district representatives of the Hertner Electric Co. Mr. Fuller will be located at 260 Kearny St., San Francisco and Mr. Krueger will have his office at 380 Plumosa Drive, Pasadena.

♦

Formerly assistant to the manager of the molded goods sales department of the Goodyear Tire & Rubber Co., W. W. Killion is now assistant sales manager of the sundries division, Tyer Rubber Co., Andover, Mass.

♦

Hannifin Corp. has recently announced the appointment of a new northwestern representative. Covering Washington, Oregon and Idaho, Jack J. Kolberg Co., is located at 1305 Dexter Ave., Seattle 9.

♦

According to a recent announcement, Borg-Warner Corp. has executed a lease with the Mueller Co. for its Decatur plant No. 3. New production facility has a floor space of 135,000 square feet.

♦

Appointed general sales manager for asbestos and rubber products in the west-coast division of Raybestos-Manhattan Inc., Littleton C. Barkley will supervise sales of the Manhattan rubber, asbestos textile, and packing and equipment sales divisions of the corporation. Until recently, Mr. Barkley was sales manager for mechanical rubber products.

♦

William W. Criswell Jr. has been appointed sales representative in the New York area for American Wheelabrator & Equipment Corp. Mr. Criswell formerly was associated with the Rochester and Pittsburgh Coal Co. as development and sales engineer.

♦

With main offices in Los Angeles, the Republic Supply Co. will represent the Hammel-Dahl Co. on the west coast. With 18 offices throughout the state of California, Republic Supply Co. will handle the complete Hammel-Dahl line of control valves and equipment.

♦

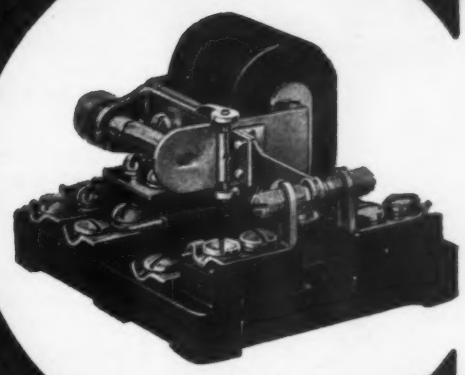
Formerly in the sales department of the Berger Mfg. Div., Republic Steel Corp., Ralph C. Braden Jr. has been appointed district sales manager in the Kansas City area. He will cover Nebraska, Kansas, western portions of Iowa and Missouri and the northeastern part of Oklahoma.

♦

Four officers of Lamson and Sessions Co. have recently received promotions. James F. Donahue, a vice president and director of the company, has been named executive vice president. George S. Case Jr., treasurer since 1942, is now vice president and treasurer. Robert G. Patterson is vice president as well as general sales

3 sensitive ALLIED RELAYS

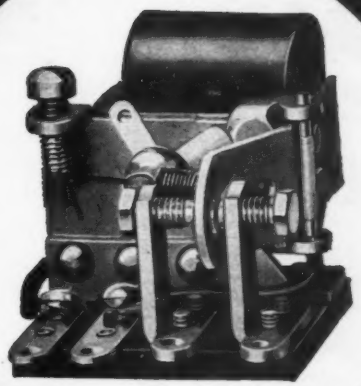
FOR A LIMITED POWER SUPPLY OR PRECISE OPERATING CHARACTERISTICS



TYPE B ALLIED RELAY

SENSITIVITY: 9 MILLIWATTS

Supplied with contact arrangements up to 2-pole double-throw. Standard silver contacts rated at 1 ampere at 24 volts DC or 110 volts AC non-inductive. Coil rating 9 milliwatts up to 38 volts DC and 0.12 volt-amperes up to 110 volts AC. Dimensions: 1¾" x 2⅜" x 2¾".

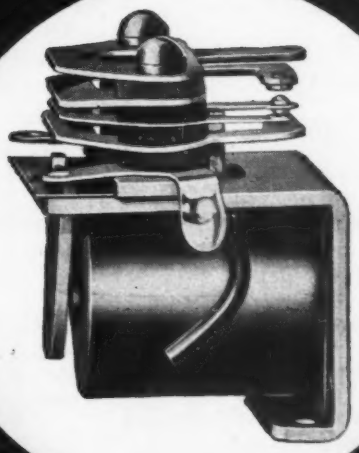


TYPE BG ALLIED RELAY

SENSITIVITY: 11 MILLIWATTS

Contact arrangements, single-pole double-throw. Standard silver contacts rated at 2 amperes at 24 volts DC or 110 volts AC non-inductive. Coil rating 11 milliwatts up to 25 volts DC. Coils available for DC operation only. Dimensions: 1¼" x 1¾" x 1⅜".

This new folder shows 24 small, compact Allied Relays with a carefully detailed table of characteristics and specifications. Write for YOUR free copy today.



TYPE F ALLIED RELAY

SENSITIVITY: 80 MILLIWATTS

Supplied with contact arrangements up to 2-pole double-throw. Standard silver contacts rated at 2 amperes at 24 volts DC or 110 volts AC non-inductive. Coil rating 80 milliwatts up to 31 volts DC. Coils available for DC operation only. Dimensions: 1⅜" x 1 1/16" x 1⅜".

AL-128

ALLIED CONTROL COMPANY, INC.

2 EAST END AVENUE, NEW YORK 21, NEW YORK

NOW priced to machinery builders as low as $50

PRICE OF ⅓ HP GRAHAM WITHOUT MOTOR

Graham VARIABLE SPEED DRIVE

PROMPT DELIVERY on sizes up to 1 H.P.

● *Here is what you get:*

√ ALL SPEEDS in infinite steps FROM TOP TO ZERO plus reverse where wanted without stopping the motor.

√ EXTREME COMPACTNESS — the only variable drive built as a streamlined extension of a standard induction motor — or available without motor.

√ EXTREME QUIET — same sound level as the motor.

√ HAIRLINE SPEED HOLDING and speed setting.

√ FULL TORQUE from top speed to zero — with doubled torque at low speeds.

√ TROUBLE-FREE PERFORMANCE — proved by ten years' use as standard equipment on leading machines.

Send for Bulletin 511. No obligation.

GRAHAM TRANSMISSIONS INC. 3754 N. HOLTON STREET MILWAUKEE 12, WIS.

manager and James M. Rowe is vice president, retaining his title of general manager of the Birmingham plant.

♦

Detroit offices have been opened by the Tocco division of Ohio Crankshaft Co. Offices are under the direction of W. K. Ginman, formerly with the induction heating division of the Budd Co.

♦

Alfred Iddles, president of the Babcock & Wilcox Co., has been elected president of Babcock & Wilcox Tube Co. He succeeds Peter D. White who died recently.

♦

According to a recent announcement, Mel W. Lewis has been appointed branch manager of the General Controls Co. Cleveland factory branch office. This office serves Ohio, western New York, northwest Pennsylvania, southeast Indiana and central Kentucky.

♦

Appointed president of Hydraulic Press Mfg. Co., Howard M. Hubbard succeeds H. A. Toulmin Jr. who resigned last November.

♦

Many sizes of Atlas roller chain, including sizes 40, 50 and 60, are now delivered directly from stock according to a recent announcement of the Atlas Chain Co.

♦

Board of directors of Electric Products Co. has recently elected R. W. Helmig a vice president and director.

♦

New plant is being erected in Houston, Texas, by Link-Belt Co. Intended to facilitate service to the southwest, the plant will be located at 5100 Wayside Drive.

♦

With offices at 75 Baker St., Providence, R. I., Leonard J. Edwards has been appointed New England sales representative for C. I. Hayes Inc. Mr. Edwards was field sales manager for General Alloys Co. for many years.

♦

According to a recent release Uri B. Grannis Jr. has been appointed manager of equipment sales for the American Brakeblok Div. of the American Brake Shoe Co., His office will be in Detroit.

♦

Foye P. Hutchinson has been elected president of the Harrington & King Perforating Co. succeeding J. M. Fuller who has retired. At the same time, J. E. Fuller was elected vice president and treasurer, and S. Harrington Jr. was elected secretary, while David K. Colesberry was appointed general sales manager.

♦

Purchase of the Cochrane-Bly Co. by the Interstate Mfg. Co. was accompanied by transfer of key personnel and equipment to the Orange, Conn., plant of the Interstate Mfg. Co.

♦

Located in the Bessemer Bldg., Pittsburgh, Robert L. Hanson will represent Allen-Bradley Co. as manager in co-operation with A. F. Landergott, and will cover the Pittsburgh industrial area for sales of motor controls.

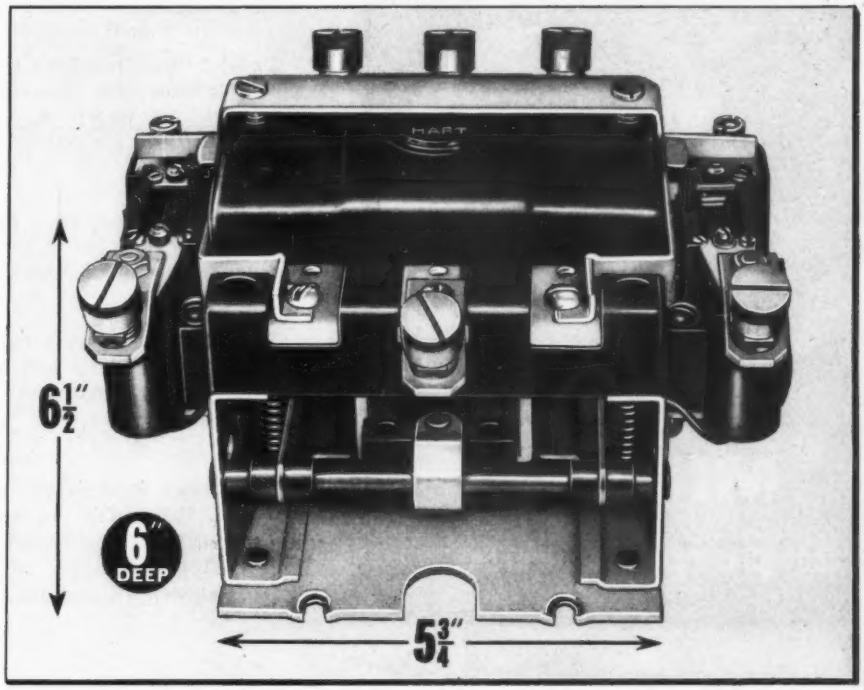
♦

Two new sales representatives have been added to the sales staff of the Saphire Products Div. of the Elgin

NEW SIZE 3 TYPE 'RA'

ARROW AH HART

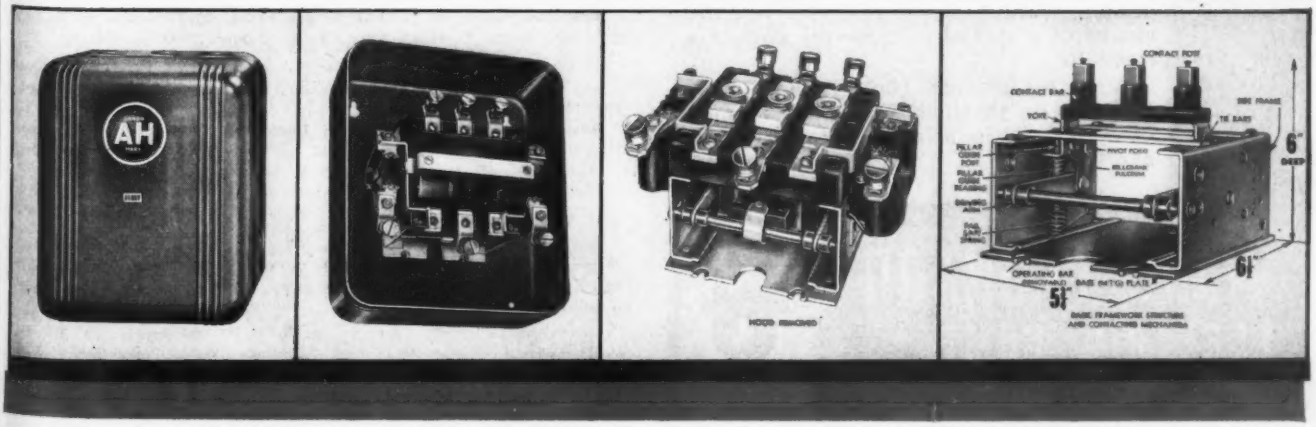
Magnetic Starter



New patented design—new Size 3 with balanced mechanism—saves 50% in installation space. Size: 5¾" width, 6½" height, 6" deep. Straight-line *horizontal action* achieved by knee-action bell crank fulcrum with roller bearing points, transmitting vertical gravity action to the horizontal contact motion by multiplied leverage. Smaller electromagnet required; less power consumed.

Heavy-duty contacts with *curved movable tips* make a broad contact line. Straight-line pillar post guidance of contacts gives positive, uniform contacting with less wear; trouble-free service. These basic advantages are followed through with the most dependable structural features for long life, simplified maintenance. Complete information in 4-page catalog bulletin — on request.

THE ARROW HART & HEGEMAN ELECTRIC COMPANY, HARTFORD, CONN., U. S. A.



MIDGET
all-purpose relay

WHERE BASIC DESIGNS IN ELECTRIC CONTROLS ARE RESULT-ENGINEERED FOR YOU

Multiple pole—positive contact, features Ward Leonard 106 Relay

An all-purpose relay, Ward Leonard's 106 Midget is designed for positive contact and long life. Solid floating contact support and compression spring loading assures positive contact with generous wipe usually obtained with individual flexible contact fingers. Normally closed contacts are free-floating for greater reliability. Available in a dozen or more multiple contact arrangements.

Here is another example of Ward Leonard "Result-Engineering". By modifying a basic design, Ward Leonard can give you the results of a special . . . for the cost of a standard.

Write for Bulletin 106. Ward Leonard Electric Co., 58 South St., Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

WARD LEONARD
ELECTRIC COMPANY
RESISTORS · RHEOSTATS · RELAYS · CONTROL DEVICES

National Watch Co. They are Harold H. Martin, who has been appointed district representative for the state of Wisconsin, and Chris Wagner who will represent the company in the south California area.

♦

Formerly sheet products manager, John Menz has been named assistant general sales manager in charge of sales promotion for Kaiser Aluminum. He will make his headquarters in Oakland, Calif.

♦

Entire spring production from two Lansdale plants has been transferred to a third plant by the Hunter Pressed Steel Co. Purpose of the change is to use the more modern equipment and facilities as well as the floor space of the new plant.

♦

District office has been opened by Cold Metal Products Co. in Indianapolis. Located in the Illinois building, the office will be under the direction of L. B. Warstler, formerly in the general sales office in Youngstown.

♦

E. L. Phillips has been appointed assistant manager of sales by the Cold Metal Products Co. for which company he was formerly production manager.

♦

The appointment of J. Ralph Griffith as sales manager of the Pioneer Pump and Mfg. Co. has been announced. Formerly, Mr. Griffith was sales manager of the Drive-All Mfg. Co.

♦

Magnesium division of Dow Chemical Co. has recently extended its system of individual sales managers by appointing J. C. H. Stearns manager of ingot sales, G. W. DeKuiper manager of wrought product sales, and T. H. Caldwell Jr. manager of die castings sales.

MEETINGS AND EXPOSITIONS

Sept. 7-9—
Society of Automotive Engineers. Tractor and Diesel Engine meeting to be held at Hotel Schroeder, Milwaukee. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

Sept. 7-9—
American Society of Mechanical Engineers. Fall meeting to be held at Reed College, Portland, Oreg. C. E. Davies, 29 West 39th St., New York 18, N. Y., is secretary.

Sept. 13-17—
American Society of Mechanical Engineers. Instruments and Regulators division meeting to be held at Convention Hall, Philadelphia. C. E. Davies, 29 West 39th St., New York 18, N. Y., is secretary.

Sept. 13-17—
Instrument Society of America. Third National Instrument Conference and Exhibit to be held at Convention Hall, Philadelphia. Richard Rimbach, 1117 Wolfendale Street, Pittsburgh 12, Pa., is exhibit manager.

Sept. 20-21—
American Society of Mechanical Engineers. Aviation Division meeting to be held at Hotel Dayton Biltmore, Dayton, Ohio. C. E. Davies.

29 West 39th St., New York 18, N. Y., is secretary.

Sept. 20-24—

Illuminating Engineering Society. National technical conference to be held at Hotel Statler, Boston. Further information may be obtained from the headquarters of the Society, 51 Madison Avenue, New York 10, N. Y.

Sept. 28-Oct. 1—

Association of Iron and Steel Engineers. Annual convention and exhibition to be held in Cleveland. Additional information may be obtained from headquarters of the society at Empire Building, Pittsburgh 22, Pa. T. J. Ess is managing director.

Sept. 27-Oct. 2—

Society of the Plastics Industry. Third National Plastics Exposition to be held at Grand Central Palace, New York City. Further information may be obtained from headquarters of the society at 295 Madison Avenue, New York, N. Y. William T. Cruse is executive vice president.

Oct. 3-6—

American Society of Mechanical Engineers. Petroleum committee of the Process Industries Division meeting to be held at Herring Hotel, Amarillo, Tex. C. E. Davies, 29 West 39th St., New York 18, N. Y., is secretary.

Oct. 6-9—

Society of Automotive Engineers. Aeronautic Meeting and Aircraft Engineering Display to be held at Hotel Biltmore, Los Angeles, California. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

Oct. 12-16—

American Chemical Society. Fifth National Chemical Exposition to be held at the Chicago Coliseum, Chicago. Further information may be obtained from exposition headquarters at 1505 South Wabash Avenue, Chicago 5, Ill. R. R. Higgins is chairman.

Oct. 18-22—

American Institute of Electrical Engineers. Midwest General meeting to be held in Milwaukee. Additional information may be obtained from headquarters of the society at 33 West 39th St., New York 18, N. Y. H. H. Henline is secretary.

Oct. 21-22—

Society of Automotive Engineers. Production Meeting and Clinic to be held at Hotel Statler, Cleveland, Ohio. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

Oct. 23-29—

American Society for Metals. Annual Convention to be held at Benjamin Franklin Hotel at Philadelphia. Additional information may be obtained from headquarters of the society at 7301 Euclid Avenue, Cleveland 3, Ohio. W. H. Eisenman is secretary.

Oct. 24-29—

American Welding Society. Annual meeting to be held at Bellevue-Stratford Hotel, Philadelphia. Further information may be secured from headquarters of the society at 33 West 39th St., New York, N. Y. M. M. Kelly is secretary.

Oct. 25-28—

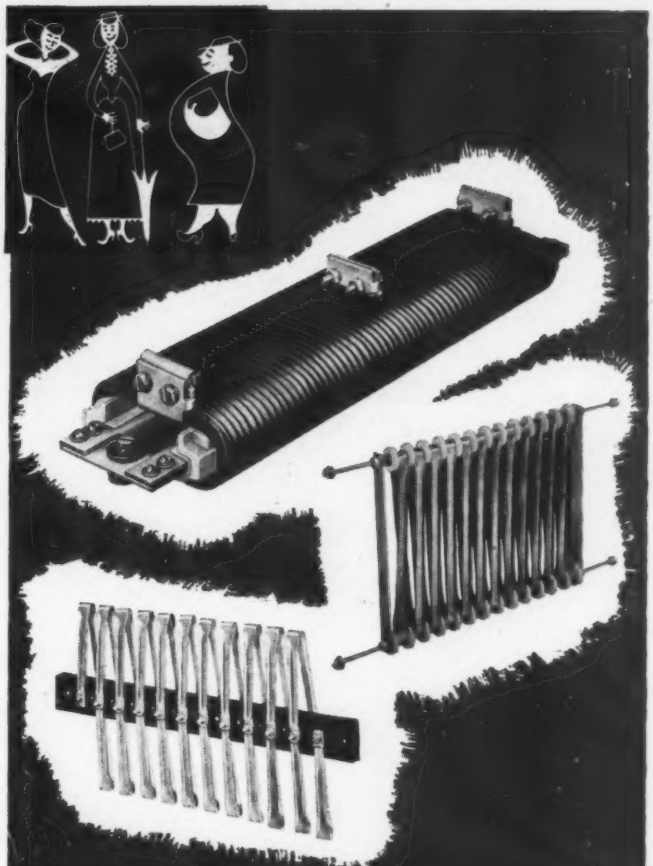
American Institute of Mining and Metallurgical Engineers. Annual meeting of the institute of metals division to be held at Hotel Adelphia at Philadelphia. Further information may be obtained from Ernest Kirkendall, division secretary, 29 West 39th Street, New York 18, N. Y.

Oct. 25-29—

National Metal Exposition to be held in Commercial Museum and Convention Halls in Philadelphia. Further information may be obtained from Chester L. Wells, assistant managing director, 7301 Euclid Avenue, Cleveland 3, Ohio.

Oct. 27-28—

Society for Non-Destructive Testing. Annual convention to be held at Hotel Adelphia in Philadelphia. Additional information may be obtained from headquarters of the society at 53 West Jackson Blvd., Chicago 4, Ill. Philip D. Johnson is secretary.



THREE
different types

WHERE BASIC DESIGNS IN ELECTRIC CONTROLS ARE RESULT-ENGINEERED FOR YOU

Ward Leonard High Current Resistors light in weight, flexible in design, wide application

Edgeohm, Loopohm or Barohm, Ward Leonard alloy ribbon resistors withstand shock. They are for high current applications. To determine the type most suitable for a specific use—the resistance, maximum current, steps required, available space, vibration and other unusual conditions should be considered.

This is Ward Leonard "Result-Engineering". So often, by slight modification of a basic design, Ward Leonard can give you the *exact* result you want—without the *extra* cost of a special.

Write for Resistor Catalog. Ward Leonard Electric Co., 58 South Street, Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

WARD LEONARD
ELECTRIC COMPANY
RESISTORS · RHEOSTATS · RELAYS · CONTROL DEVICES

CASTINGS BY Continental

DESIGN WITH Continental IN MIND!

No matter what you design for castings . . . design with Continental in mind as your *sure* source for steel castings! Continental's foundry and machine shop facilities are especially suited to the production of large, heavy and intricate carbon or alloy steel castings as well as production runs from standard patterns. Special physical properties . . . special grain structures . . . heat treating, quenching, drawing of even large scale castings . . . rough or full finish machining . . . it's an everyday task at Continental. When you design for castings, rely on Continental as your *sure* source! For problem-solving counsel on castings, submit your early plans to Continental. No obligation, of course!

Design with an eye to supply!

Almost the entire line of Marion Power Shovels features Continental Steel Castings! When the designs are tough . . . and the castings must "take it" . . . it pays to cooperate and know your source of supply. Design is by Marion Power Shovel Co., Marion, Ohio . . . Castings by . . . Continental.

Continental

Continental FOUNDRY & MACHINE CO.

CHICAGO · PITTSBURGH

Plants at E. Chicago, Ind.; Wheeling, W. Va.; Pittsburgh, Pa.

DESIGN ABSTRACTS

Electronic Lathe Controls

As better turning tools came into existence, as the variety of alloys was increased, and as maximum cutting speeds were established, it became apparent that a fixed number of specific spindle speeds did not meet all of the requirements of industry. Consequently, the attention of machine tool engineers was directed along the lines of variable-speed drives.

Our company sought as earnestly as any for a reasonable solution to the requirements of a variable-speed drive. At the insistence of customers we even built a considerable number of special machines, although we had to proceed without knowledge of how to correct certain drive weaknesses which persisted. However, these machines within their limited capacities served definitely to show the way for future developments, and more or less convinced us that the best solution to the problem would be found along electrical lines.

Variable-Voltage Drive

Our first big-scale offensive along this line took place in the redesign of a 10-in. precision toolmaker's lathe. This machine had been built and marketed with various types of variable-speed drives, and approximately eight years ago was changed over to a variable-voltage drive utilizing a d-c motor and a motor-generator set operating from an a-c power source. Design of this lathe features independent speed control to the spindle when operating in either forward or reverse direction. Overall speed range is 100 to 1.

During the years of its application, many improvements have been made in the drive until today it has become a highly successful application. In our opinion it was the first really significant development along the lines of a variable-speed drive on lathes, and we appreciate the help of electrical manufacturers in bringing it to its present-day perfection.

While we are still utilizing this drive in a large number of our present-day machines, it had been clearly evident to us for some time that there were further advantages which would only be secured when the motor-generator set could be replaced by a tube control. So sure

To see what happens

These pictures show a pawl slipping off ratchet during service. It bounded so that maximum force was exerted when the contact area was small. Change in pawl shape cured the trouble.

Built-in argon lamp flashes time-pulses of desired frequency on edge of film for absolute time measurement.

when parts wear out too fast... *use the Kodak High Speed Camera*

By taking up to 3000 pictures a second, this precision instrument makes possible accurate visual analysis of mechanical action . . . or of any high speed motion

To see why a ratchet tooth slips . . . to observe the wearing action of gears running at high speed . . . to help in solving almost any industrial high speed, time-motion problem . . . use the Kodak High Speed Camera.

Because it takes up to 3000 pictures a second—with exposures as fast as 1/15,000 of a second—this camera will record continuous action of most industrial high speed machinery with exceptionally high rendition of detail.

Because it is easily portable . . . because it is easy to handle . . . any engineer or competent technician can use it in laboratory or plant for making the most accurate observations of chemical, electrical, or mechanical action (using conventional internally silvered photofloods for lighting). And because it uses 16mm. film, pictures are readily projected—for study and discussion—with any standard 16mm. projector.

To give you an idea of how the Kodak High Speed Camera can be used to magnify time so that you can see what happens when liquids flow. . . when incandescent metal is forged . . . when a welding bead is deposited . . . when materials yield or stretch . . . write for the new booklet, "Magnifying Time." It's free.

EASTMAN KODAK COMPANY
Industrial Photographic Division, Rochester 4, N. Y.

HIGH SPEED MOVIES

. . . another important function of photography

"Kodak" is a trade-mark

MAIL THIS COUPON FOR FREE BOOKLET

Eastman Kodak Company
Rochester 4, N. Y.
Please send me ☐ your new, free booklet on the Kodak High Speed Camera;
☐ your 16mm. demonstration reel of examples of high speed movies.

Name_____
(please print)

Company_____

Dept._____

Street_____

City_____

State_____

19

Kodak

SWIFT • SURE • STURDY • SILENT • SMOOTH • STEADY

PLAN *Silent* CAT-QUIET OPERATION IN EVERY BASIC DESIGN

You've often remarked that no piece of equipment can be superior to its component parts...

You appreciate the broad recognition and acceptance of BCA Ball Bearings in industry . . .

You know you can tell your engineers to draw upon our half-century of experience in friction control practices, encompassing many varied fields of industry . . .

You, who insist upon continuous, full-capacity, trouble-free operation, know this can be assured by specifying BCA Ball Bearings.

BEARINGS COMPANY OF AMERICA
LANCASTER, PENNSYLVANIA

BCA RADIAL · ANGULAR CONTACT · THRUST BALL BEARINGS

were we that the elimination of noise and vibration associated with mechanical rotating parts could be achieved that we made it the next step in our own research into variable-speed drives.

Electronics systems to control the flow of power from an alternating-current system to a direct current-system have been in existence for several years, and have been continually improved insofar as fineness of operations is concerned. Unfortunately, however, these improvements and modifications have in most cases resulted in a more bulky and expensive piece of equipment. Often electronic control equipment is many times larger than the motor it is controlling, and considerably larger than electromechanical rotating equipment used to accomplish the same purpose.

Unit Lacked Overload Capacity

In our case the only unit small enough in size to fit into the space available in the toolmaker's lathe employed single-phase, full-wave rectification. The maximum ampere rating of the grid-control rectifier tube was 6 amperes, the largest capacity tube available at the time. Utilizing two tubes, the rating of the unit could be brought up to 12 amperes, the full-load rating of the 3-hp motor which was to be operated with it. This left no reserve whatever for acceleration or overload without seriously affecting tube life.

To overcome this handicap, current limit was included in the control scheme. However, it was found that, if the settings were such as to utilize somewhere near the maximum capacity of the tubes, the control of the motor was adversely affected. The reserve needed to accelerate the spindle, as well as to take care of occasional overloads, simply was not present. The large number of control tubes and their associated circuits which had to be employed resulted in a bulky piece of equipment utilizing every available bit of space in the base of the machine. Moreover, the control was divided into a number of units and mounted separately which, of course, introduced assembly and maintenance difficulties.

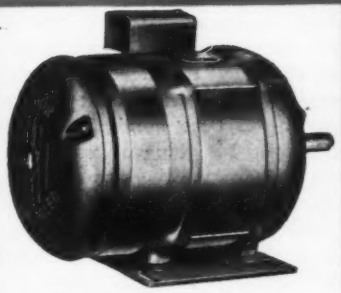
Three-Phase Unit Too Large

As the limitations of the unit just described became more apparent, another unit employing three-phase rectification was investigated. In the opinion of our electrical engineers, it was quite an improvement electrically over the first unit. However, to fill all the drive requirements, the

Streamcooled
TRADE MARK

MOTORS

ARE 100% TOTALLY ENCLOSED ...yet they can't clog and cause trouble



Streamcooled, round frame, 1/3 to 3/4 h. p., 1 phase, 3 phase and direct current.

Streamcooled face mounted; Single phase 1/3 to 7½ hp., Three phase 1/3 to 20 hp., Direct Current 1/3 to 3 hp.

Streamcooled, single phase, 3/4 to 7½ h. p.

Streamcooled, three phase 3/4 to 20 hp.

Many motors are actually choked to death!

But never a BALDOR STREAMCOOLED Motor.

Conventionally designed motors, with air passageways, constantly draw in dust, dirt, lint and all sorts of foreign matter.

Then the motor becomes "choked" and loses its efficiency, heats up and soon goes dead.

Such motors require frequent dismantling for cleaning . . . wasting servicing time and often slowing up or stopping production.

BALDOR STREAMCOOLED Motors *can't* inhale dust, dirt, lint or foreign matter because they are *totally enclosed* . . . non-clogging . . . cool-operating . . . because the outer-mounted fan forces air over the entire EXTERIOR of the motors.

BALDOR ELECTRIC COMPANY · ST. LOUIS, MO.

District Offices in Principal Cities

Baldor
BETTER MOTORS

FOR MORE THAN A QUARTER OF A CENTURY

Tumbling barrels completely fabricated by Ampco Metal, Inc. of Ampco-8 sheet, welded with Ampco-Trode corrosion-resistant arc welding electrodes. Studs are welded to base of barrels for mounting on tumbling turntable.
Ampco Metal
makes tumbler-barrel costs tumble

Using Ampco rolled sheet cuts maintenance and replacements

Tumbling barrels are used to clean rivets, screws, nuts, and a variety of similar small parts. Formerly, they wore out quickly—because of the cleaning solution's corrosive action, and the abrasive effect of swirling metal parts. Replacement costs were high, until the manufacturers switched to tumbling barrels fabricated with Ampco-8 sheet. This durable, corrosion-resistant alloy solved their expensive replacement problem in jig-time. That is just one more case of the money-saving value of Ampco Metal's unique physical properties. Hundreds of companies use durable Ampco Metal and Ampcoloys in their own products as selling features—and in their production equipment as insurance against heavy maintenance and replacement costs on parts subject to wear.

Call in your nearby Ampco engineer for cost-cutting suggestions. Write for complete information on Ampco castings, extrusions, forgings, sheet, and fabricating service.

Ampco Metal, Inc.

Department MD-8 • Milwaukee 4, Wisconsin

Field offices in principal cities

unit was so large that it had to be housed in a separate control cabinet and placed on the outside of the lathe or apart from it. In fact, the size of the control cabinet almost equalled that of the lathe, and naturally a very substantial price was not missing.

Realizing full well the difficulties which always surround the design and development of anything new, our electrical engineers, nevertheless, decided to try their own luck at developing a tube control for this application. In general, we wanted a unit to supply power to a direct-current motor required to operate over a wide range of speed settings, with the speed at each setting remaining substantially constant over a wide variation of power requirements. Such things as quick acceleration for forward and reverse speeds, fast starting and stopping, and the like, needed to be considered. In addition, size and cost of the device had to be kept to a minimum.

It was apparent that our needs could best be filled by using a single-phase circuit design, if a grid-controlled rectifier tube with a high enough ampere rating could be acquired. The first attempt was made with mercury-vapor tubes having a maximum rating of 12 amperes. Utilizing two of these tubes adequately met load requirements but, when the unit was put under test, it was found the operating temperature limits of the mercury-vapor tubes were too narrow, and that for this reason the unit would not be practical.

New Tube Satisfied Needs

About this time a 16-ampere xenon-filled tube became available. It was exactly what we were looking for. Our circuits were immediately modified to employ these tubes and, utilizing commonly available control tubes, resistors, capacitors, etc., a new unit was put under test which, after a few months of further refinement, resulted in the control we have today.

Our desires and requirements in this size unit have been fully realized without sacrificing speed range or regulation. In fact, we believe we can show a substantial improvement over mechanical-electrical rotating equipment. The quiet, smooth operation afforded by tube control, together with its sensitivity and quick response, make it a valuable asset.—*From a paper by Kermit T. Kuck, vice president — engineering, The Monarch Machine Tool Co., Sidney, O., presented at the recent Westinghouse Machine Tool Forum in Buffalo.*

Taking stock of steel stock

Ball bearing inspection at Federal begins with laboratory sampling of the SAE No. 52100 steel on arrival. Micro structure, carbon content and hardness are analyzed and confirmed as standard, then segregated and stored according to heat lot and number. Similar heat lots with uniform structure, hardness and machinability are run together on batteries of automatic screw machines.

Taking stock of steel stock is just one of *over 100 production, inspection and cleaning operations* that go into the making of every Federal Ball Bearing.

All along the line Federals are crush tested to determine load bearing strength, and resistance to compression and distortion. Sensitive gauges guard eccentricity and parallelism of inner and outer rings. Bores and O.D. are held to strict dimension to assure proper operating fit and running clearances. And *every* bearing is run at high speed on a test stand to measure its quiet performance. That's why at Federal, *every fourth operator has to be an inspector*. Why, too, when you specify Federal, you blueprint smooth, friction-free performance into your equipment...whatever the assignment.

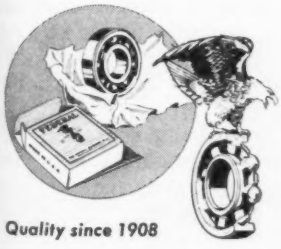
Write for our catalog "K." It illustrates and describes the completeness of Federal's line. Better still, ask the Federal representative in your vicinity to call and "talk it over."

THE FEDERAL BEARINGS CO., INC. · POUGHKEEPSIE, NEW YORK

Makers of Fine Ball Bearings

REPRESENTATIVES LOCATED AT

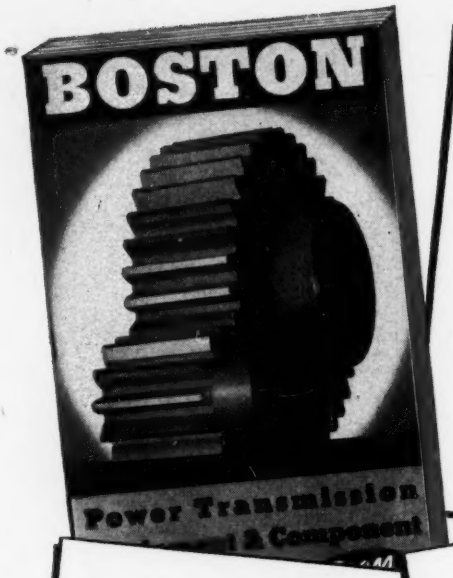
Detroit: 2640 Book Tower–26 • Cleveland: 402 Swetland Building–15
Chicago: 8 S. Michigan Ave.–3 • Los Angeles: 5410 Wilshire Blvd.–36



Quality since 1908

FEDERAL BALL BEARINGS

ONE OF AMERICA'S LEADING BALL BEARING MANUFACTURERS



Simplifies Design Problem

"The Development Superintendent was amazed by the way I simplified the problem of designing our new textile machine," says P. W. "By using stock products listed in the Boston Gear Catalog, I cut design time 'way down. There were 101 groups of products and 4326 separate stock items listed — with specs and data on each. It certainly cut out a lot of engineering work . . . and we really beat our budget figures on that job!"

Saves Drafting Time

"A design job came to my board marked 'RUSH' . . . with the due date only 3 days away," writes F.R. "It seemed impossible because the driving elements looked plenty complicated. But in checking my Boston Gear Catalog, I found the whole drive could be made up of stock parts. All I did was copy off the specs from pages 28, 126, 168 and 254. That job got done in six hours!"

Send in your experience in cost, time, or work savings made possible by the Boston Gear Catalog.

Manufacturer Cuts Costs

E. P. L. writes: "I give the Boston Gear Catalog direct credit for boosting my profits. For years we'd made every component in our mixing machines. But one day, looking for a quick source of high-quality commercial gears, I checked the Boston Gear Catalog and found drive components that exactly filled my needs . . . and at a lower price than we could make them! When I found I could get quick delivery from a nearby distributor, I standardized on the Boston Gear line. The savings in engineering and production time, plus lower unit costs, add up to higher profits for me."

Put this great data book to work earning for You!

FREE This valuable data book which shows you how to make important savings in design, manufacturing and maintenance costs using Boston *Stock* Component Machine Parts. Contains 101 separate groups of products — gears, chain, sprockets, speed reducers, etc. — 4326 individual items — engineered, mass produced to custom standards for your application. Also contains much valuable working data for designers, engineers, maintenance men.

Name ..... Position .....

Company .....

Street .....

City ..... Zone ..... State .....

BOSTON GEAR WORKS

One of the world's most complete lines
62 distributors in major cities

86 Hayward Street
Quincy 71, Massachusetts

NEW MACHINES

And the Companies Behind Them

Air Conditioning

DUST SEPARATOR. Employs wet method to remove dust and foreign particles from air, mixes water with dust-laden air, and by centrifugal action, washes out foreign matter. Contains no filters or bags. Industrial Engineering Co. Inc., Indianapolis.

COOLING FAN. 30-inch, in satin ivory, for mounting on walls or in upper or lower portion of double-hung windows. Also available are 24 and 30-inch commercial and industrial air circulators. Emerson Electric Mfg. Co., St. Louis.

Bakery

BAKING OVENS. All-purpose. Have 18 trays, 26 x 112 in.; oil fired. American Machine & Foundry Co., New Haven 9, Conn.

BREAD DEPANNER. By mechanical means depans 1500 straps of open-top bread an hour. Takes strapped pans of any size and overall length up to 30 in. Automatically spaced and carried to top. The Petersen Oven Co., Franklin Park, Ill.

VERTICAL MIXER. Heavy-duty. Equipped with pushbutton thermal overload switch; has four speeds and automatic type of transmission. Capacity, 20 to 80 qts. Champion Machinery Co., Joliet, Ill.

MOULDER-PANNER. Eliminates sheeter roll scrapers due to plastic rollers. Reverse sheets the dough piece. Quik Seal Inc., Kansas City 3, Kans.

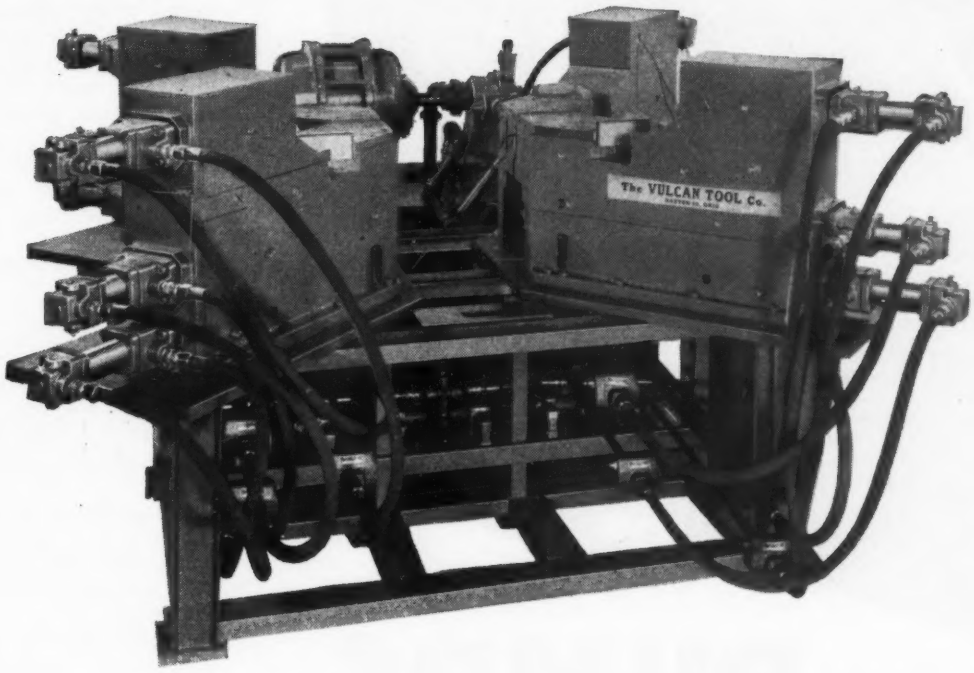
Book Binding

PAPER COUNTER. High-speed, electronic. For paper, cards, labels, stationery and other sheet material. Material to be counted is riffled or stacked to provide step-like edge. Stylus is then run down the steps and up to 300 counts per second are registered in table model, box-like electronic counter. Potter Instrument Co., Flushing, N. Y.

PAPER JOGGING MACHINES. In two styles. Flat deck models, all-purpose, for all kinds of jogging. Angle models or automatic models eliminate jogging operation entirely. Designed expressly for gathering forms. M. L. Abrams Co., Cleveland 14.

ROUNDER AND BACKER. Has new cluster gear, changing speeds, and clutch control for instantaneous stopping and starting. The Craw-

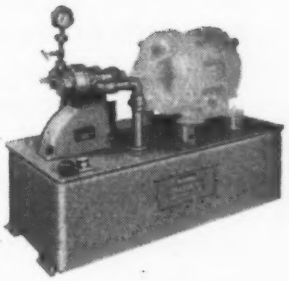
GEROTOR does the job!



...IN THIS HYDRAULIC CORNER-FORMING UNIT

manufactured by the Vulcan Tool Company, Dayton, Ohio

In the production of refrigerator food compartment liners, this Vulcan special machine tool saves money, time and space . . . forms 4 corners every 7 seconds, simultaneously. The unit employs GEROTOR hydraulic devices throughout . . . multiple cylinders and valves (shown above) activated by a complete pump unit (right).



GEROTOR engineers specialize in saving you money, time and space . . . with hydraulic and pneumatic applications that **prove** GEROTOR does the job!

Write for Catalog Section G-105 (Hydraulic Pump Units), 102 (Cylinders), 200 (Valves).

hydraulic pumps, motors, valves & cylinders • air valves & cylinders

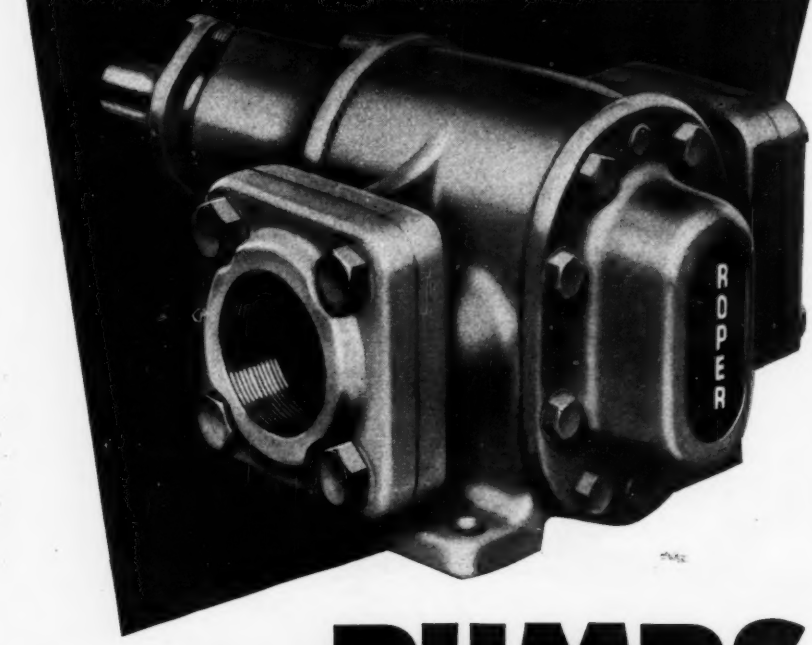
GEROTOR MAY CORPORATION • BALTIMORE 3, MD.

GEROTOR

Save Space...

REDUCE POWER COSTS WITH

ROPER SERIES "K"



ROTARY PUMPS

Compact, built-to-take-it Roper Series "K" pumps are especially adaptable to confined spaces... reduce power costs... cover a wide range of jobs pumping clean liquids at capacities up to 50 g.p.m. They are self-lubricated by liquid pumped, handle total suction lifts up to 25 feet, come equipped with mechanical seal or packed box — with or without relief valve.

Venturi suction and discharge principle provides properly proportioned distribution of liquid pumped, thereby minimizing energy loss through turbulence, cavitation, or friction.

Series "K" pumps can be direct connected, belt or chain driven... operate in either direction... available in ¾ to 50 g.p.m. sizes, pressures to 150 lbs. p.s.i., speed 1740 r.p.m.

SEND FOR CATALOG

Illustrated literature describes models and specifications of pumps in the Roper line. Ask for yours today.

ROPER *Rotary Pumps*

GEO. D. ROPER CORP., 248 Blackhawk Park Ave., Rockford, Ill.

ley Book Machinery Co., Newport, Ky.

MECHANICAL COLLATOR. For volume collating of 2 to 52 pages in one operation. Has 5 removable trays, each holding approximately 500 sheets, permitting gathering of paper ranging from 3 x 8½ in. to 8½ x 14 in. Collating speed is 12,500 per hour. Thomas Mechanical Collator Co., New York 7.

SPIRAL BOOKBINDING MACHINE. Binds books from 5/16-in. to ½ in. thickness. Fully automatic; to 1000 books per hour with one operator. Equipment Div., Spiral Binding Co. Inc., New York 1.

PAPER CUTTERS. Either shear or vertical cutting may be utilized and changeover is 15-min. operation. National Cutter Div., Frank M. Hill Co., Walpole, Mass.

Bottling

AMPULE MACHINE. Technique is partial or total blowing into mold, using a variable-speed, dual-drive motor. Produces ampules of every type and shape, standard and special, up to 2400 per hour. Kahle Engineering Co., North Bergen, N. J.

CONTAINER DRIER. Continuous, automatic. As containers enter machine, they are rotated by worm feed passing slanting air jet from which cutting blast of air removes moisture. Handles various sizes of containers. Machine is 8 ft long and 1 ft wide. Barry Wehmiller Machinery Co., St. Louis.

Communications

ELECTRONIC ROBOT. Consists of recorder, player, control and amplifier, 25 recording blanks, microphone, cable, desk stand, electric eye, speaker head and electric eye light source. Operates with electric eye or automatically. St. Louis Microphone Co., St. Louis.

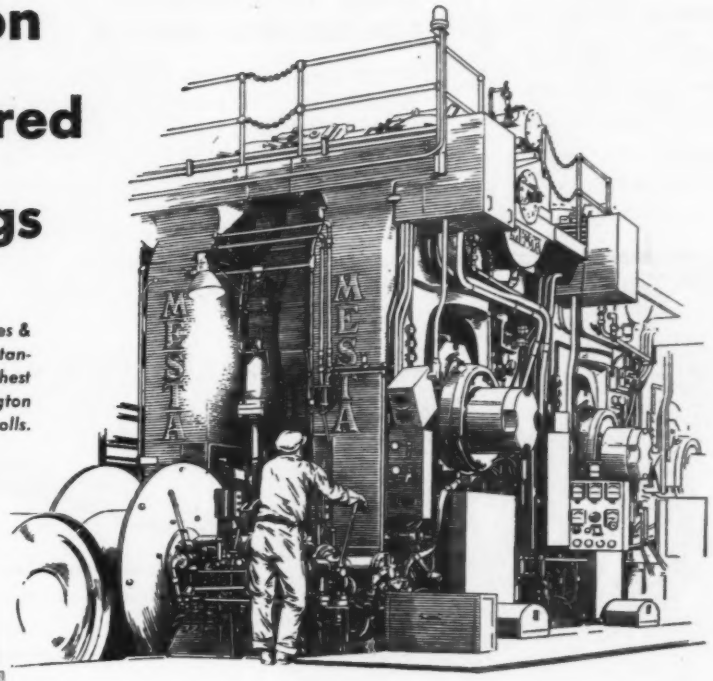
Construction

EARTHMOVER. Electrically-controlled. Medium-sized, high-speed unit used with Model E16 scraper which has capacity of 13.3 cu yds or 16 tons. Powered by 150-hp 6-cyl diesel engine, with four forward speeds ranging from 2.19 to 17.3 mph. R. G. LeTourneau Inc., Peoria, Ill.

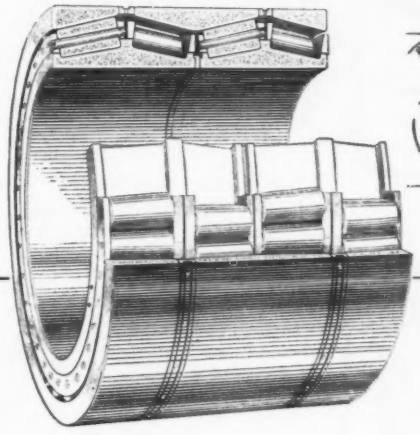
TRUCK MIXER. High discharge type with revolving hopper for both charging and discharging. Hopper is supported from end of mixing drum cone and moves with drum as truck frame weaves during operation; thus hopper remains in alignment with drum. Blaw-Knox Co., Pittsburgh.

TRUCK - CRANE. Remote - controlled.

Fastest Rolling Mill Sets Tonnage Records with Torrington Four-Row Tapered Roller Bearings



Built by Mesta Machine Company for the Jones & Laughlin Steel Corporation, this five-stand tandem cold strip mill attains the world's highest speed production with the help of Torrington four-row Tapered Roller Bearings on work rolls.



. . . rapid acceleration and long runs with minimum time-out for maintenance are advantages of high-capacity Torrington Bearings.

COLD-REDUCTION of steel strip at 6,250 fpm is the world's record speed, attained by the five stand tandem cold strip mill built by Mesta for the Aliquippa Works of the Jones & Laughlin Steel Corporation. The strip mill work rolls are equipped for high speed and long service life with Torrington Tapered Roller Bearings.

The tremendous load-carrying capacity, low starting and running torque and long service life of these Torrington Bearings help assure the long runs, high speeds and uninterrupted operation that mean greater uniformity in gage and quality of finished strip. The rapid acceleration—from 300 to 4500 fpm in six *seconds*—not only reduces to a minimum the amount of off-gage strip which results from speed changes, but also reduces power requirements.

The specialized experience of Torrington's engineers is available in applying these and other bearings in the Torrington line to heavy-duty equipment used in the oil, steel, paper, machine tool and construction industries. Call or write the nearest Torrington office.

THE TORRINGTON COMPANY
South Bend 21, Ind. • Torrington, Conn.
District Offices and Distributors in Principal Cities

TORRINGTON BEARINGS

SPHERICAL ROLLER · TAPERED ROLLER · STRAIGHT ROLLER · NEEDLE · BALL · NEEDLE ROLLERS

RITCO FORGINGS

REMEMBER RITCO FOR

Special Bolts, Nuts and Studs • Alloy Steel Fasteners • Milled Body Bolts
Drop and Upset Forgings
Complete Machine Facilities

MADE TO BLUEPRINT FOR RELIABLE SERVICE

RITCO Upset Forgings contribute to the excellent performance of many well known products including this Buckeye Drainage Ditcher, by Gar Wood Industries, Inc., whose "fingers" by RITCO withstand severest service. Smooth and free of flash, RITCO Forgings are made accurately to your specifications in weights from ¼ lb. to 15 lbs. Estimates gladly submitted.

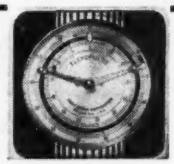
RHODE ISLAND TOOL CO.
148 WEST RIVER ST., P. O. BOX 1516
PROVDENCE 1, R. I.

Serving American Industry Since 1834

EAGLE TIMERS for Controlling Industrial Processes

REPEAT CYCLE

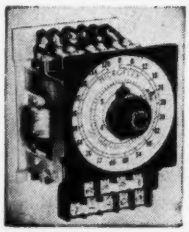
Use where ON-OFF operation is continuously repeated. The ON time and OFF time are each adjustable on the dial. (FLEXOPULSE)



COUNTER

Use for limiting a process to an exact number of operations. The counter contact opens after 1 to 400 electrical impulses as selected on dial. Automatic spring reset.

(MICROFLEX COUNTER)



MICROMETER DIAL

Provides exceptional timing accuracy where a circuit is to close or open with a time delay. Timing adjustable over wide range.

(MICROFLEX TIMER)

MULTIPLE CIRCUIT —ADJUSTABLE

Use where several circuits are to close in a predetermined sequence. Time of closing and opening each circuit is adjustable.

(MULTIFLEX TIMER)

To reduce costs and improve quality of your products by automatic TIME-COUNT control . . .

★ Write for catalogue Bul. 291.
★ Send for details of your control problems to Eagle for recommendations.
★ Consult Eagle representative in principal cities.

EAGLE Signal Corp.
MOLINE ILLINOIS

One engine used for travel and one for crane service. Has hydraulic control. Harnischfeger Corp., Milwaukee.

Dairy

SOAKER-WASHERS. Available in both automatic and semi-automatic types, in sizes which will wash from 16 to 72 bottles per minute. Girton Mfg. Co., Millville, Pa.

Domestic

ELECTRIC WATER HEATER. 40-gal, table-top. For use in kitchens of houses without basements. Measures 24 x 25⅛ x 36 in. and has 3½-in. backsplash. General Electric Co., Bridgeport 2, Conn.

VACUUM CLEANER. Junior model adapted to small homes. Weighs 13¾ lb. Has triple action: Tapping dirt loose, sweeping by revolving brushes, and cleaning by suction. The Hoover Co., North Canton, O.

CLOCKS. Three types. One an alarm for cabinet, table or desk, or boudoir; another for home use enclosed in mahogany case, striking on the hour and half-hour; another for wall use in homes, offices, stores and restaurants. Seth Thomas Clock Div., General Time Instruments Corp., Thomaston, Conn.

Industrial

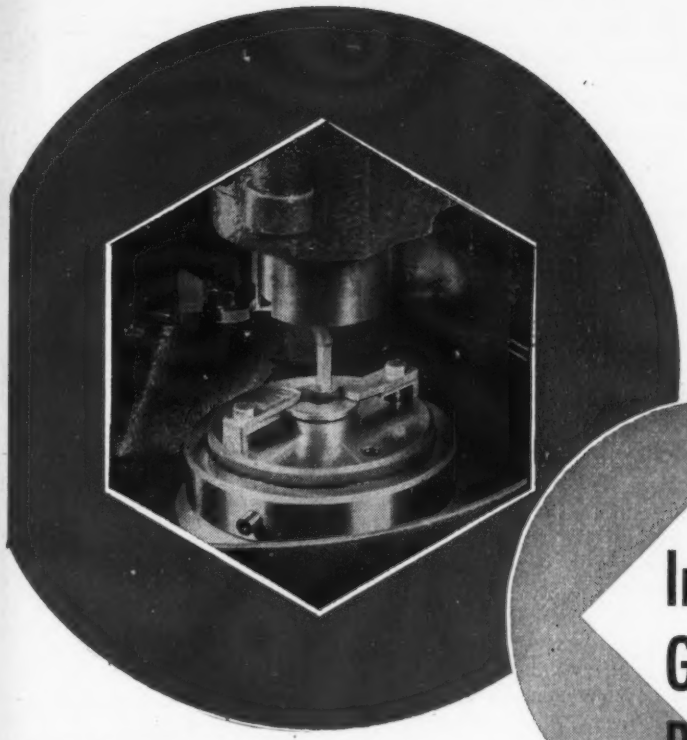
GENERATORS. Gasoline engine driven. For supplying power in handling scrap or pig iron with magnet cranes. Available in six sizes, ranging from 5 kw to 25 kw. Furnished with 6-v battery ignition, pushbutton starter, radiator, and fuel tank. Motor Generator Corp., Troy, O.

Materials Handling

POWER INDUSTRIAL TRUCK. Combines low-lift platform and crane. Lifts load from floor level to hook height of 8 ft, with radius of 45 degrees left or right. Can lift and transport loads weighing 3 to 5 tons. Elwell-Parker Electric Co., Cleveland.

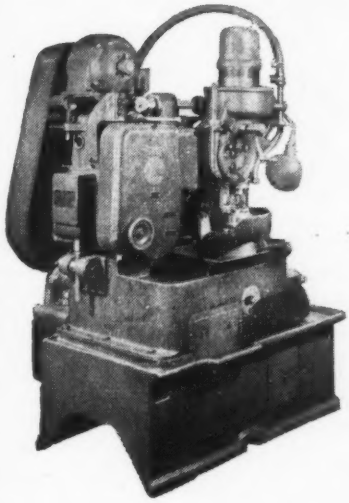
AUTOMATIC INDEXING MACHINE. Vertical; for drilling, counterboring, reaming and milling. Fifteen-spindle multiple head; power-driven multi-station index table. Automatic continuous cycle, or intermittent by pushbutton control. W. K. Millholland Machinery Co., Indianapolis 5.

ABRASIVE BAR CUTTER. Hand operated, wet type. Five-inch wheel flange, wheel guides, automatic work stop, automatic pump, hydraulic work clamp. Coolant tank separate, wheel mounted. Handles



Internal Contours Generated to a PRECISE TAPER

Generating hexagonal trim dies on the Fellows Gear Shaper at The Cleveland Cap and Screw Company.



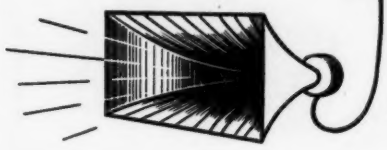
The high-precision ability of the Gear Shaper to generate symmetrical, angular or irregular contours, internal as well as external, carries suggestions to designers in many industries. Hexagon or square trim dies, for instance, can be generated to a controlled taper, as low as ½ degree, with close-tolerance duplicating accuracy.

The versatility of the Gear Shaper on non-gear jobs opens the door to the practical production of many intricate shapes... increases the scope of low cost machining at the designers' command. A reading of our illustrated book, "The Art of Generating with a Reciprocating Tool" will prove of interest to every production-minded design engineer. The Fellows Gear Shaper Company, Head Office and Export Dept., Springfield, Vermont. Branch Offices: 616 Fisher Bldg., Detroit 2; 640 West Town Office Bldg., Chicago 12; 7706 Empire State Bldg., New York 1.

Fellows

THE FELLOWS METHOD . . . MACHINES AND TOOLS FOR ALL OPERATIONS FROM BLANK TO FINISHED GEAR

facts speak LOUDEST



At least one type of Molybdenum high speed steel is listed and promoted on a basis of equivalent and interchangeable performance with tungsten steel, by makers of high speed steel.

Users' reports of Molybdenum high speed tools *everywhere* indicate that performance at least equals and in many cases betters that of tungsten tools.

The heat treatment of Molybdenum high speed steels is basically the same as that of tungsten steels. There is nothing in the treatment to confound those who are familiar with the heat treatment of tungsten types.

Molybdenum high speed steels save money in production—for proof send for our FREE booklet.

Climax Molybdenum Company
500 Fifth Avenue · New York City

MAIL THIS COUPON

Please send me a copy of your FREE BOOKLET

Name .....

Company .....

Address .....

HS.2

MOLY

bar to 2-in. diameter; tubing to 3½-in. diameter. Andrew C. Campbell Div., American Chain & Cable Co., Bridgeport, Conn.

SPECIAL MACHINE TOOL. Bores, drills, spot faces cylinder blocks. Multiple station, automatic. Transfers hydraulically; all units interlocked; screw type chip conveyors in welded steel base. Produces 40 units per hour. Snyder Tool & Engineering Co., Detroit.

INTERNAL GRINDER. Hydraulic; automatic; 16-inch swing; 15-inch total wheel slide traverse. Cylindrical slide construction, pressure lubricated. Electrical cycle control. Bryant Chucking Grinder Co., Springfield, Vt.

RIVET INSERTER. Automatic. Inserts 12 rivets in automotive wheel assembly. Six automatic feed hoppers; hydraulically-actuated plungers pick rivets from hopper chutes, insert them in rivet holes. Two-hundred wheel assemblies per hour at 80 per cent efficiency. Snyder Tool & Engineering Co., Detroit 7.

MANY-PURPOSE POWER TOOL. Portable. Speeds from 1600 to 2600 rpm maintained regardless of load. With utility shaft, bores holes, sands, grinds, buffs, etc. Weight, 50 lb. Used to drive other machines. Continental Motors Corp., Detroit.

OSCILLATING-TROUGH CONVEYOR. Positive-action eccentric type. Driven by Link-Belt Electrofluid Drive through chain or V-belt. Trough widths, 12 to 48 inches; single trough lengths, to 100 ft. Trough is either pan type or constructed with channel steel sides; is leakproof with dust-tight covers. Link-Belt Co., Chicago 1.

SPECIAL-PURPOSE MACHINE. For applying clamps to air brake hose and other industrial hose of smaller diameter; driven by compressed air from shop air line. Incorporates control gages. Punch-Lok Co., Chicago 7.

DRILL PRESS. 15-in. Features depth stop which operates on feed pinion between two lower quill bearings, eliminating any side thrust or deflection of drill point. Spindle has travel of 4 in. with four speeds from 630 to 4850 rpm. Reypo Corp., Los Angeles 45.

DIE CASTING MACHINE. High-pressure hydraulic. Furnished either with a hot metal end for casting zinc, tin or lead, or as a cold chamber machine for casting aluminum, magnesium or brass; or if a universal machine is desired both types of ends can be furnished and

in making of your screw machine parts and complete products

U.S. AUTOMATIC

Our men have accumulated many valuable years of experience. Enlist their experience the next time you need screw machine parts. Send us your prints today

BAR CAPACITY 3/64" to 5 1/2"dia.

ALL SECONDARY OPERATIONS

Micrometers
Automobiles
Truck bodies
Aircraft
Appliances
Toys
Hardware
Refrigeration
Stoves
Water heaters
Tractors
Radios
Industrial ove[illegible]
Phonographs
Blowers
Scales
Steam boilers
Rolling mills
Watches
Fishing reels
Spray guns
Counting devices
Roller bearings
HP.motors
Casters
Electrical controls
Pressure gauges
Valves
Bicycles
Cranes
Rock crushers
Cement mixers
Turbines
Generators
Lawn mowers
Door locks
Door hinges
Power tools
Thermostats
Carburetors
Typewriters
Cameras

U · S · Automatic CORPORATION Amherst, Ohio

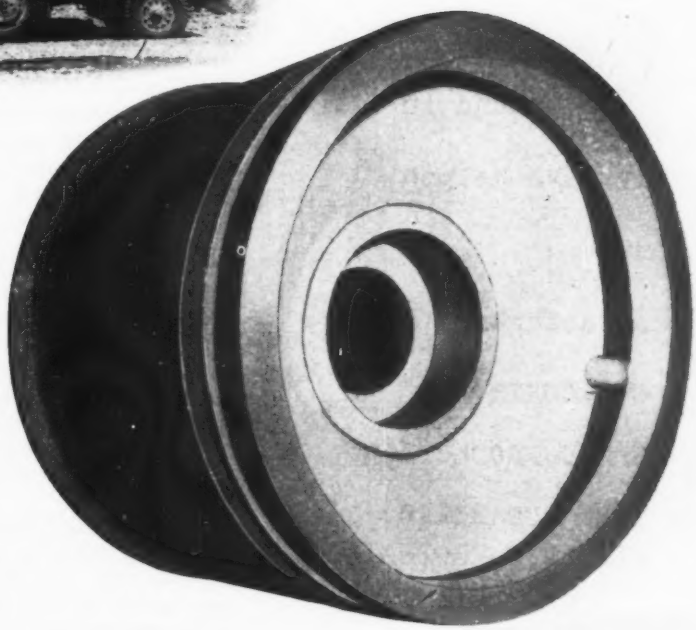
40-Ton Earth Movers Roll On WELDED WHEELS

by **AMERICAN WELDING**

● Massive 1,000-pound wheels are but one of many applications of American Welding's "Controlled Technique" in the manufacture of highly specialized weldments. The fabrication of wheels by welding makes it possible to design for specific loads at minimum cost.

Strict conformity to specifications and close tolerances provide savings because less machining time is required.

If you use wheels, rings, bands, assemblies or special weldments, chances are that our 31 years of welding research will be able to show it is to your advantage to call on American Welding.



Your requirements — quantity, prints, specifications — will receive our prompt quotation.

★

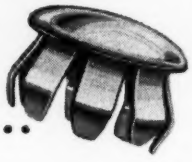
Send for 16-page illustrated booklet

THE AMERICAN WELDING AND MANUFACTURING COMPANY

130 DIETZ ROAD • WARREN, OHIO

If you have a Fastener Need . . .

that's suitable to Volume Production...



It may pay you to let our Design Engineers have a hand in it.

They have helped many manufacturers

★ CUT COSTS

★ SPEED PRODUCTION

★ TURN OUT FINER FINISHED PRODUCTS

UNITED-CARR FASTENER Corp.
CAMBRIDGE 42, MASSACHUSETTS

MAKERS OF DOT FASTENERS

quick changeover made from one to other. Cleveland Automatic Machine Co., Cleveland 12.

ABRASIVE CUTTING MACHINE. Wet type. Consists of oscillating swing frame, work feeding and holding mechanism, cooling system, and hydraulic work clamping and wheel feed unit. Campbell Machine Div., American Chain & Cable Co. Inc., Bridgeport, Conn.

Testing

PROJECTION LIGHTMETER. Portable; flashes light measurements on screen. Three major parts: Small, hand-size light-cell probe; D'Arsonval-type, self-contained microammeter; and standard SVE 100-watt 2 by 2-in. slide projector. Normal range, 0-100 foot candles. Weight, 8 lb. General Electric Co., Schenectady 5.

Textile

MEASURING AND INSPECTING MACHINE. Foot control for variable speeds. For inspection, machine unrolls goods at slow speed. Has forward and reverse drive on a single hand control. Handles all fabrics, heavy or light, rolls or folds, and is constructed in standard widths of 48 and 60 inches. Cutting Room Appliances Corp., New York 10.

Welding

SEAM WELDER. Automatic, cylinder-forming. Ejects flat steel sheets as welded cylinders at 600 to 1500 per hour, depending on length of cylinder and thickness of material. Equipped to produce 26 to 16-gage mild-steel cylinders ranging from 11¼ in. in diameter by 14 in. long to 22 in. in diameter by 37½ in. long. Federal Machine & Welder Co., Warren, O.

WELDERS. Three-phase balanced power for resistance welding. Permits greater range of shapes and sizes of work. Taylor-Winfield Corp., Warren, O.

PROJECTION WELDER. One cycle of current to complete weld. Special 175-kva water-cooled transformer. Low-inertia spring head incorporates slide within slide. Standard T-slot platen; adjustable stroke cylinder. The Federal Machine and Welder Co., Warren, O.

Woodworking

DOUBLE SURFACER. Bed powered by ½-hp motor, pushbutton controlled. Three smooth steel feed rollers. Numerous feed rates. Balanced forged steel cutter heads; patented shearing bar. Capacity, stock 30-in. wide by 14-in. thick. Buss Machine Works, Holland, Mich.

BOOK TWO

PRODUCTION PROCESSES

Their Influence on Design

By
ROGER W. BOLZ
Associate Editor, Machine Design

To assist the designer in evaluating the multitude of processing methods presently available and help attain the eminent advantages of maximum economy, accuracy and speed in the manufacture of tomorrow's machines, this reprint has been made available. Comprising the second fifteen parts in this series of articles which has been appearing in MACHINE DESIGN, the volume is designated as Book II and matches in size and format the reprint of the first fifteen parts.

CHAPTERS
Abrasive Belt Machining
Hot Upsetting
Electroforming
Metallizing
Impact Extrusion
Production Milling I
Production Milling II
Barrel Finishing
Press Brake Forming
Precision Boring
Thread and Form Rolling
Powder Metallurgy
Rotary Swaging
Roll-Die Forging
Wire and Ribbon Forming

Price $1.00 Postpaid

Order Your Copy Today

MACHINE DESIGN
Book Department
Penton Building, Cleveland 13, O.